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Engineering in the Dairy Industry

REFRIGERATED AIR EMPLOYED TO COOL STORAGE ROOMS IN NEW CHICAGO DISTRIBUTING STATION OF THE BOWMAN DAIRY CO.

CONSUMERS OF DAIRY PRODUCTS, and especially those residing in the larger cities, have of late been concerned considerably regarding the continually rising prices demanded for these commodities. Naturally many factors are at work to which this may be attributed and while, due to the existing economic conditions, many of the underlying causes cannot be eliminated or remedied, even to a slight degree, others it has been found may be readily corrected if the proper means are employed.

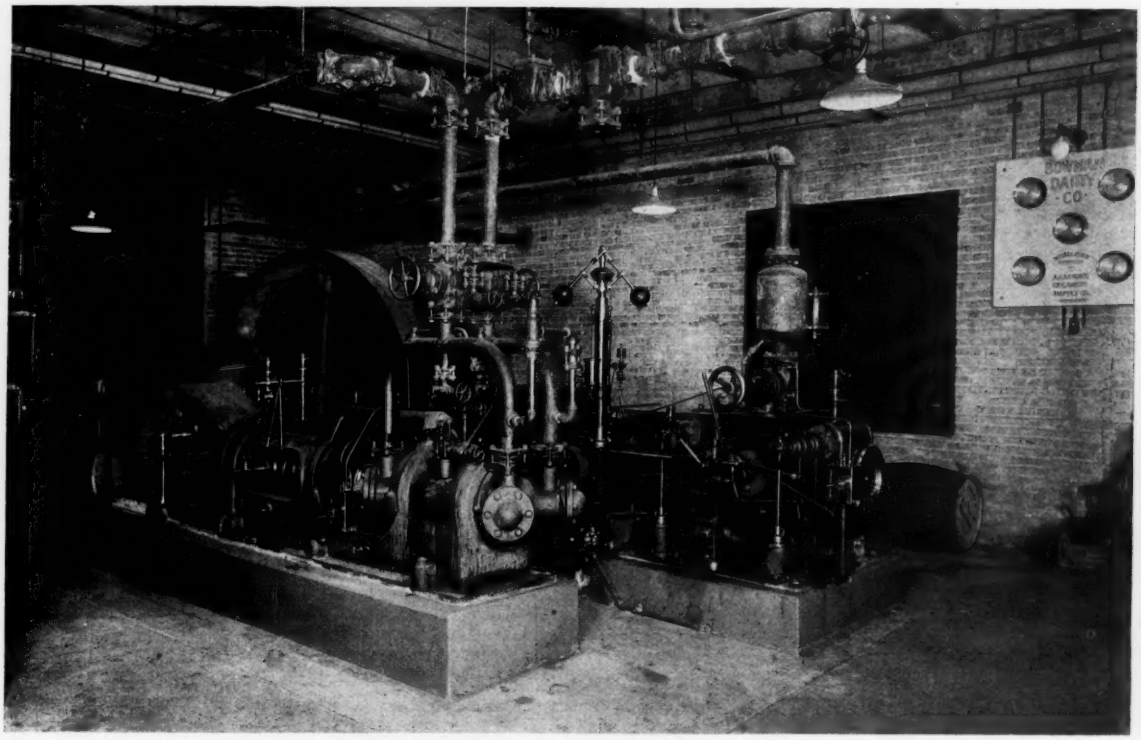


FIG. 1. AMMONIA COMPRESSOR IN DISTRIBUTING STATION OF BOWMAN DAIRY CO.

One of the most important and vital factors involved in this question is the matter of distribution, and as soon as ways and means are found whereby this phase of the industry can be placed upon the simplest conceivable basis the net cost to the consumer is reduced. Realizing these facts and desiring to co-operate as much as possible with their customers in an attempt to maintain a minimum price, many dairy companies operating in our larger cities have established distribution centers, each serving its particular territory, and thereby eliminating duplication of deliveries and materially reducing the cost of distribution. Due to the perishable nature of the commodities handled and the fact that storage facilities must be provided to keep them in proper condition, these distribution centers embody many features similar to those found employed in cold storage warehouses. This

is exemplified in the case of the newly erected distribution station of the Bowman Dairy Co., Chicago, four stories in height and occupying about one-fourth of a city square at the northwest corner of West Ontario and North La Salle streets. From here deliveries of milk, cream, butter and eggs are made by nearly one hundred wagons and automobile trucks to the territory bounded by Diversey avenue on the north, 12th street on the south, the Chicago River on the west and Lake Michigan on the east.

steam generating, refrigerating and sewage disposal plants comprise the major and most important portion of the mechanical equipment. This is located, as shown in Fig. 2, on the La Salle street side of the basement, with the boiler room which houses the boilers, the feed pump, heater and coal and ash storage, separated from and at a lower level than the engine room.

Steam is generated at a pressure of 150 lb. gage in one of two 60 in. by 16 ft. Pennsylvania Boiler Works horizontal tubular boilers, each rated at 80 hp., and is

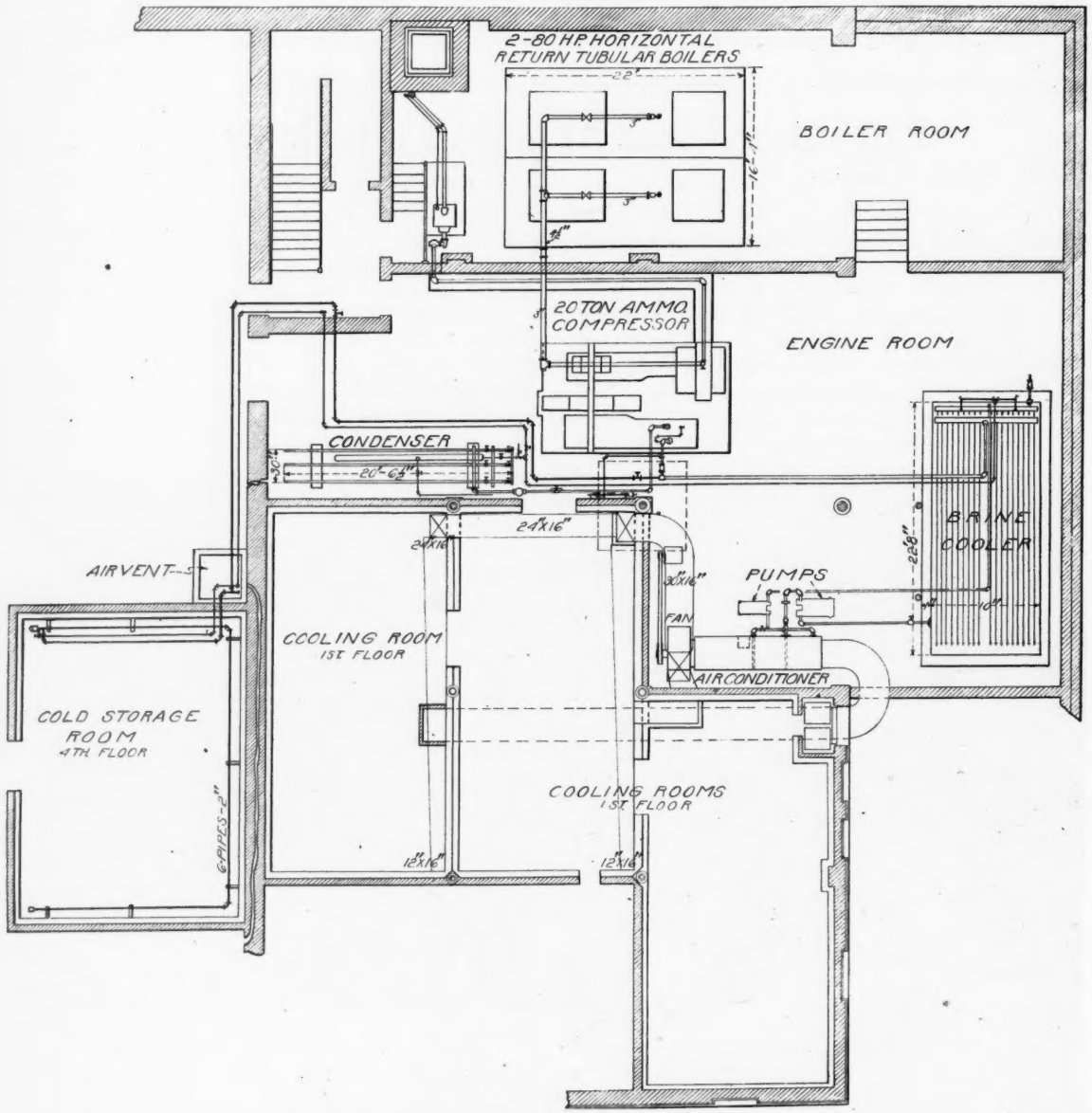


FIG. 2. PLAN OF POWER PLANT AND STORAGE ROOMS

As may be expected, in order to provide the service requirements of an institution of this kind, much equipment of a nature particularly interesting to engineers has been installed. And, although at the present time electric current used for light and power is being purchased from the local public service company, complete

delivered through 3-in. leads carrying Crane non-return check valves to a 4½-in. header which serves a heating main and a 3-in. lead connecting with the engine cylinder of the ammonia compressor. The former is fitted with a 3 by 6-in. Illinois Engineering Co.'s reducing valve wherein the pressure is reduced to 2 lb. before the

steam is delivered to the system, which is of the gravity return type and which consists of approximately 3835 sq. ft. of radiation. The returns from this system, together with makeup taken from the city mains, are passed through an open type Cochrane heater wherein the temperature of the water is raised to about 210 deg. F., and are then delivered to the boilers for reuse by either a 5¼ by 3½ by 6-in. Deane duplex pump or a Penberthy injector, as operating conditions may require. Generally the pump is employed for this purpose and in

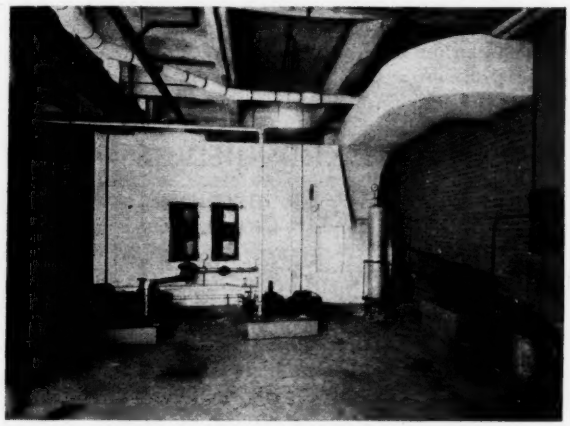


FIG. 3. AIR CONDITIONER USED FOR REFRIGERATION PURPOSES

order to provide a continuous and positive feed, the layout of the piping is such as to allow feeding through either the fronts of the boilers or the blowoff connections.

Before entering the heater, the returns from the heating system are caused to pass through a water leg provided to avoid any excess back pressure on the heater.

The blowoff leads, which tie in with a main header connected to a 30-in. by 6-ft. blowoff tank, are each equipped with Jenkins Bros. Y and Lunkenheimer gate valves.

Directly in front of the boilers, shown in Fig. 4, is a coal storage space having a capacity of about 100 tons of coal. This is fired into the furnaces by hand, and in order to comply with a local ordinance regarding the elimination of smoke each boiler is equipped with a smoke-consuming device consisting of four ¼-in. jets of steam playing over the fire at the front of the furnace.

Ashes also are handled manually, although original plans call for the installation of a hydraulic elevator or some other form of conveyor to raise them to the street level and thereby eliminate much unnecessary labor.

Refrigerating Equipment

A feature of particular interest in this plant is the system of refrigeration employed for cooling the three storage rooms located on the first floor, above the engine room. Instead of the usual brine circulating system, the desired results are accomplished by the circulation of air refrigerated in a Carrier Air Conditioner placed as indicated in Fig. 3 and consisting essentially of a housing of copper, lined with duck-covered 3-in. cork and having overall dimensions of about 14 by 3 by 9 ft. high and containing the necessary sprayers and eliminators.

Brine is taken from the cooling tank and by means of a Buffalo Steam Pump Co.'s centrifugal pump direct connected to a 7½-hp. General Electric motor, and after being caused to pass through a pocket strainer, is delivered to the sprayers at a pressure of 20 lb.; here it comes into intimate contact with the circulating air, which thereby is reduced to a temperature very nearly corresponding to that of the brine. After the air passes through the eliminator chamber, where all moisture is removed, it is taken up by a 36-in. Buffalo Forge concoidal blower belted to a 7½-hp. General Electric motor and is forced through the system.

After being used the brine is removed from a collector pan and by means of a Buffalo Steam Pump Co. centrifugal pump direct connected to a 3-hp. electric motor, also of General Electric make, is returned to the cooling tank. In order, however, to operate most efficiently, provision has been made by means of thermostatic control whereby as long as the temperature of the brine remains at 36 deg. F. or below, the supply from the cooling tank is cut off and only local circulation maintained by the smaller of the two centrifugal pumps. With a rise in temperature of the brine above 36 deg. F., the supply line is again caused to open and circulation from the cooling tank re-established.

Connected to the discharge side of the fan is a duplex outlet which supplies cold air to two ducts, one having dimensions of 30 by 18 in. and connecting with two of the storage rooms, the combined cubical contents of which is 7290 cu. ft., while the other opening, which has a section of 30 by 16 in., supplies the third room, the overall dimensions of which are 24 by 20 by 9 ft. high. In two of the rooms the cool air is distributed through

FIG. 4. VIEW IN BOILER ROOM

openings in a tapering duct suspended at one side near the ceiling and in such a manner as to cause the air to pass to the opposite side of the room, downward and again back to the starting side, whence it is removed through a register placed in the floor and connected to a 36 by 24-in. return duct.

Ordinarily a temperature of from 34 to 36 deg. F. is maintained in these rooms, excepting when and where milk and cream is stored in bottles, when the temperature is maintained at from 40 to 45 deg. F. Dampers

placed in the individual distributing ducts and under thermostatic control are depended upon to maintain the desired degree of refrigeration.

In the cooling room on the fourth floor, which has overall dimensions of approximately 20 by 20 by 12 ft. high and is used exclusively for the storage of butter and eggs, the direct brine circulating system is employed, six-pipe-high coils of 2-in. pipe being attached to the walls of three sides of this room. A temperature of about 40 deg. F. is here maintained, and as in the construction of the other cooling rooms, a 6-in. layer of cork on top, bottom and sides is employed to provide the necessary insulation.

Compressor, Condenser and Brine Tank

Installed in the engine room, as may be seen in Figs. 1 and 2, is a single 9 by 18-in. Vilter ammonia compressor having a rated capacity of 20 tons and direct connected to a 10 by 30-in. Corliss steam engine. And for use in connection with this is a double pipe condenser built up of three stands, 18 ft. long and 12 pipes high;

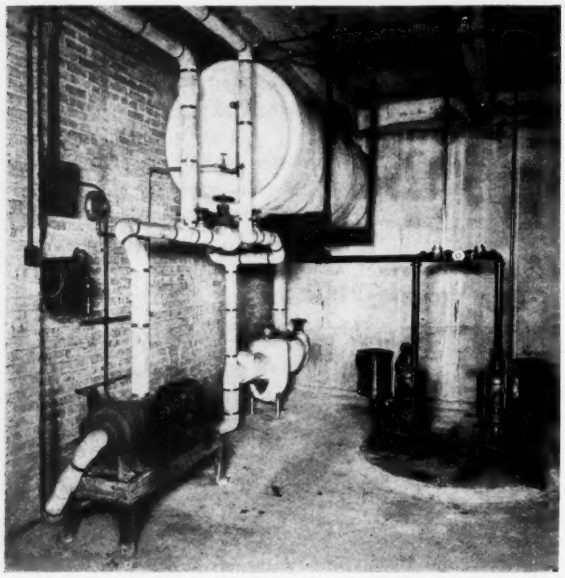


FIG. 5. WATER PRESSURE TANK AND SEWAGE DISPOSAL PUMP

1 and 2-in. pipes are employed in its construction.

The brine-cooling tank has dimensions of approximately 24 by 10 by 6 ft. high and contains 4320 ft. of 1¼-in. extra heavy pipe in the form of 98 coils, each 12 pipes high and 20 ft. long.

Miscellaneous Apparatus

To insure an adequate and satisfactory domestic water supply at all times, the entire fourth floor of the building and all of the toilet rooms are connected to the pressure tank shown in Fig. 5. This, which has a capacity of 750 gal., is served by a two-stage centrifugal pump of Yeomans make, driven by a 2-hp. Roth Bros. electric motor, which also operates a small air compressor used to maintain a pressure of from 40 to 50 lb. per square inch.

All sewage from above the second floor flows directly into the city sewers, while that from the lower floors and the blowoff tank discharge drains into a receiving tank having a capacity of 1800 gal. From here the accumulations are removed by one of two Yeomans vertical centrifugal pumps and discharged into the city mains. The pumps employed for this purpose are each operated by electric motors under automatic float control and are rated at 1¼ and 1¾ hp., respectively.

Two Otis automatically operated electric elevators have been installed. One of these, used exclusively for freight, has a capacity of 4000 lb., while the other, the passenger elevator, has a capacity of 1000 lb.

The entire electrical and mechanical equipment of this installation is in charge of A. W. Conroy, chief engineer.

Fire Extinguishers

Their Use in the Power Plant. By I. S. Chamberlain

In practically all power plants, the danger of fire is ever present but, due to the infrequency of fires, this danger is often underestimated. Most large plants maintain private fire fighting apparatus; but in the case of smaller plants such equipment is usually confined to portable fire extinguishers. Due to these extinguishers being so seldom required for service, the matter of keeping them in first-class working order and ready for instant service is liable to be neglected unless some systematic record of this work is kept. They should be regarded as an important part of the plant's equipment and be given attention accordingly.

Next in importance to keeping extinguishers properly charged is the matter of their location. When one is required for service in an emergency there is no time to be lost in hunting them. In some plants they are not kept in suitable locations but are shifted about until they are almost certain to become hidden by other articles and in that way are next to impossible to find when required in a hurry.

A permanent station should be designated for each extinguisher, in conspicuous and easily accessible locations. When they are mounted on posts or columns in large rooms, in order that their locations may readily be found from all parts of the room the post on which an extinguisher is hung can be made conspicuous in a neat and effective manner by painting a wide band, preferably bright red, all the way around it near the top. Locations of fire extinguishers can thus be determined at a glance from almost any section of the room.

Even on floor spaces of medium areas, all the posts or columns are usually very similar in appearance and unless they are viewed from certain angles the presence of an extinguisher on any particular column might very easily be overlooked by a person not entirely familiar with the surroundings.

Regardless of the size of a plant every effort should be made to promote the general efficiency of whatever fire fighting equipment is at hand.

Many designers make their engines too heavy by putting metal where it is not needed.—The Gas Engine.

Coal and Its Selection

Coal Formation and Qualities, Proper Selection, Economical Use. By Walter N. Polakov

According to an old Chinese custom, the groom has to pay for his bride a certain sum of money, which is in direct proportion to her weight. In America our coal dealers sell their product to us on a similar basis. Weight, rather than available heat energy, is the sole consideration. Yet we buy coal for its heat, and hence our first question should be, "How much heat can we get out of this coal?" and after this has been answered we should fix the price.

What would you think of a housewife who paid her butcher the same price per pound for "shin" as she paid him for porterhouse steak? Not much! Well, no superintendent wants to be classed with such a dear old lady, but he will be if he allows his coal dealer to ship him all kinds of "black stuff that burns" on the same contract.

Let us now see what coal is, and how it came to exist. Since the fourth day of creation vegetation has covered the swampy earth in abundance. Geological disturbances of the surface of the earth gradually submerged this vegetation, and its place was taken by a new growth which, as time went on, was also submerged.

On the fifth day of creation, animals were created, and among them was one, *Micrococcus carbo* (carbo meaning black), a micro-organism, or bacterium, which is found in decayed animal and vegetable matter, and which is the cause of such decay.

These little agents belong to the large tribe of saprophytic fungi, or bacterial ferments, and it is due to their work that the submerged vegetation was gradually transformed into peat and later into various grades of coal. Throughout the transformation the chemical composition of the decaying matter was continually changing; the oxygen and hydrogen being present in large amounts in the wood, and in a very small amount in the resulting coal. Table A shows the proportion of hydrogen and oxygen to 100 parts of carbon which exists in the coal at its various stages of growth.

TABLE A

Substance.	Parts of Carbon.	Parts of Hydrogen.	Parts of Oxygen.
Wood	100	12.18	83.07
Peat	100	9.85	55.67
Lignite	100	8.37	42.42
Wales coal	100	4.75	5.28
American anthracite	100	2.84	1.74

Let us look at this table. As we compare the elements oxygen and hydrogen with the principal ingredient carbon, we see that while the coal is still in the womb of nature it has 12.18 parts of hydrogen and 83.07 parts of oxygen, the last being a gas which will neither burn or develop any heat. After birth we have "baby coal," or *peat,* and he has already gained in strength because he has shaken off some of his oxygen and hydrogen. In his early youth he is known as *Lignite,* and by this time he has lost half of his babyish characteristics, because he now has only 42 parts of oxygen instead of 83 parts. As he becomes still further advanced in years, he gradually loses more and more of his "nonsenses," and finally graduates into the "Methusalem" class of the family, becoming *American anthracite.* As such he deserves to be highly honored because he is very useful; but, alas, like most old people, he has his own peculiarities and is very hard to handle.

Coal, as we find it, occurs in seams, or veins, and as a result of what happened to it during its formation the coal of one seam may be quite unlike that of another. Under the influence of heat from the great fires in the bowels of the earth (raging even now, as our volcanic eruptions show, and sometimes spoken of by our reverend clergy as the "fires of hell") some of the veins of bituminous coal lost a great part of their gaseous substances (volatile matter) and became a kind of coke, which was very tightly compressed by the upper strata of the earth. Others, however, happened to be imbedded in solid rock, which did not permit any of the gaseous substances to escape, and the coal of such veins remained rich in volatile matters.

We are now at the point when it is necessary to say a few words about the chemical elements of which coal is made up. If an ultimate analysis of the "dry combustible" part of the coal is made it will be found to contain the elements listed in Table B. This analysis does not include ash, earthy matters and moisture.

TABLE B

(1) Name of Element	(2) Chemical Symbol	(3) What Happens in the Furnace	(4) Combined with Oxygen to Form	(5) Amt. of Oxygen Required to Burn 1 lb., in lb.	(6) Amt. of Air in lb. Required to Burn 1 lb.	(7) Heat Developed by complete burning of 1 lb. in B.t.u.
Carbon	C	burns	CO_2	2.66	11.57	14,600
Hydrogen	H	burns	H_2O	8.0	34.80	62,000
Oxygen	O	doesn't burn	....	....	.....	.....
Nitrogen	N	doesn't burn	....	....	.....	.....
Sulphur	S	burns	SO_2	1.0	4.35	4,050

Glancing at Table B for a moment, let us make sure that we recognize all the "animals" mentioned. Column 1 is all right, because it contains nothing more than five "old friends," although the last one, sulphur, is one we like best when he is far away. In the second column is shown the shorthand name which the chemist uses. The third column talks for itself. The fourth shows some more "Chinese" names or chemist's symbols—CO_2 being the gas we like to find in the stack, H_2O the water we drink, and SO_2 the choking gas which results from burning sulphur. The fifth column gives us the number of pounds of pure oxygen necessary to burn completely 1 lb. of each substance, and column 6 shows the number of pounds of air required to do the same thing. Column 7 shows the amount of heat resulting in each case as found by test.

There is another type of analysis in general use, which is easier to make and more quickly done than the ultimate analysis and which gives enough information to direct firemen. This is called the "proximate analysis" and is used to divide the coal into several parts by means of the following methods. A pulverized sample of the coal is first heated gently, exposed to air, in order to drive out the *moisture*—H_2O. Next it is heated moderately in an enclosed vessel, not admitting any air, in order to drive out the *volatile matters.* The third step consists of burning the remains of the first

two steps in an intense heat in the presence of oxygen, thus determining the amount of *fixed carbon*. The residue from this operation is *ash*.

In this country the various kinds of coal are classified according to their proximate analysis, the criterion being the percentage of volatile matters and carbon. Table C gives the limiting percentages of these two substances in the different kinds of coal in general use, along with their average heating (H. V.) value in B.t.u. per lb.

TABLE C.

Class of Coal	% Fixed Carbon	% Vol. Mat.	Av. H.V. B.t.u. per lb.
Anthracite	92.5-97.0	7.5- 2.5	11000-13200
Semi-anthracite	87.5-92.5	12.5- 7.5	12500-13500
Semi-bituminous	75.0-87.5	25.0-12.5	13500-14800
Bituminous	50.0-70.0	50.0-25.0	12500-14000
Lignite	Up to 50.0	50.0 and over	7000-11000

It is appropriate to remark that the name "bituminous," as applied to coal, is a mistake. This class of coal has the peculiarity of softening or apparently

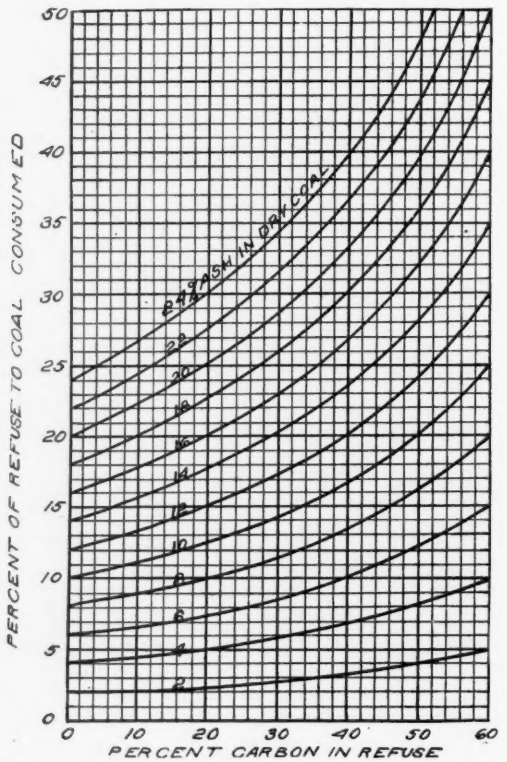


FIG. 1. RELATION OF CARBON IN REFUSE TO TOTAL COAL CONSUMED

fusing, long before it reaches the temperature at which actual combustion takes place. At this point the hydrogen in the coal unites with carbon, forming *hydrocarbons* both of solid and gaseous character (the latter being similar to marsh gas), but it has been proved that nothing analogous to "bitumen" exists in the fuel.

The volatile matters are of great interest to the users of coal for the following reasons:

1st—They require a very high temperature for combustion,—marsh gas ignites at 1233 deg. F.,—and since this is seldom reached in ordinary boiler operation, a large part of the volatile gases reach the cool water heating surface, before burning, and are lost.

2nd—They differ greatly in composition:—some of them are very high in available hydrogen, and can develop up to 45,000 B.t.u. per lb., while others are high in nitrogen and oxygen, and instead of burning, simply absorb a great deal of heat. (The average heating value of volatile matters, if CH_4 burns to CO_2 and H_2O, is 23,600 B.t.u. per lb.)

3rd—In burning they produce a long flame and result in a great deal of smoke.

4th—Their heating values vary considerably, and hence the heating value of the coal of which they form a part cannot be computed from the proximate analysis, but it can be computed from the ultimate analysis.

Dulong gives the following formula for computing the heating value of coal from its ultimate analysis

$$H = 146\,C + 620\left[H - \frac{O}{8}\right] + 40.5\,S$$

in which: H = B.t.u. per lb.
C = per cent of carbon
H = " " " hydrogen
O = " " " oxygen
S = " " " sulphur

Table D shows a comparison taken from the U. S. goelogical survey of the computed heating values, and the heating values determined by test for a few different samples of coal.

TABLE D

Kind of Coal.	Heating Value in B.t.u. per lb. Test Result.	Computed.
Diamond seam	12,933	12,924
Mammoth No. 1	12,818	12,816
Mammoth No. 2	13,682	13,515

The amount of *fixed carbon* as determined from proximate analysis of a certain sample is not the same as the amount of *carbon* shown by an ultimate analysis of the same sample. There are two reasons for this variation: first, part of the *fixed carbon* may combine with other elements not readily volatilized; second, part of the carbon volatilized jointly with some of the other volatile matters. Table E, made by the U. S. Geological Survey, plainly illustrates the variation between *fixed carbon* and *carbon*.

TABLE E

Kind of Coal	Prox. Anal. Vol.	F. C.	Ultimate Analysis C	H	S	N	O	Ash
Charleroi Bituminous	54.28	56.03	77.32	5.09	1.19	1.45	7.62	7.33
Semi-Bit	17.75	70.12	77.42	4.00	2.09	1.29	3.58	11.63
Anthracite	7.27	74.32	75.21	2.81	0.77	0.80	4.08	16.33
Scranton Diamond Seam	2.55	84.40	81.47	1.97	0.56	0.70	2.25	13.05
Mammoth No. 1	1.58	84.71	80.82	1.91	1.07	0.68	1.81	13.71
Mammoth No. 2	1.19	90.75	86.78	1.63	0.95	0.71	1.96	8.06

Ordinarily the per cent of *fixed carbon* is smaller than the per cent of *carbon*, especially in bituminous and semi-bituminous coals. The two are nearly equal in anthracite and graphite coals, and in coal of very old formation the *fixed carbon* is occasionally greater.

As was stated before, the heating value of coal cannot be accurately determined from the proximate analysis; yet certain kinds of semi-bituminous coals show a remarkable relation between their percentage of fixed carbon and their evaporating capacity. In other words, the number representing our boiler efficiency is very close to the number representing the percentage of *fixed carbon* in our dry coal. This is not a scientific truth, but a good practical average with certain kinds of coal.

Sulphur, almost always present in coal, varies in amount from 0.5 to 5.0 per cent and is generally

regarded as harmful. It occurs combined with iron (as iron pyrites) or with lime (as sulphate of lime). With a very few exceptions, coal containing iron pyrites, yields a red ash. About ¼ of the amount of sulphur present forms a gas during combustion, which attacks and damages the iron parts of the furnace. The remaining ¾ is usually found in the ash, which it has helped to fuse into large clinkers, thus choking the supply of air and impairing combustion.

Ash is the unburnable residue of coal, and is composed of mineral matters. If a piece of coal be photographed by means of an X-ray, two things will appear: first—dark parallel planes of a substance, which later forms the ash; second—transparent layers between these planes which are made up of *combustible.* (*Combustible* is an analytical term, and refers to coal free from ash or moisture or "A. & M. free.") The fact that coal is built up of alternate strata of ash and combustible shows very clearly that it was originally formed by successive deposits of prehistoric forests, interspersed with mineral matters, which resulted from either volcanic action or some other natural catastrophe. But we are not intensely interested in this phase of the ash question. To us, ash means extra work, particularly when it clinkers and fuses with the fire brick walls, thus reducing the possible boiler efficiency 3 to 5 per cent. Furthermore, ash of any composition has to be removed—thus reducing the value of the coal by the cost of such removal.

Chemical composition of the ash is seldom ascertained, and has been studied so little in the past that we cannot definitely say which composition is harmful, and which is not. But it is an established fact that such ingredients as alumina and silica are respectively responsible for the so-called exothermic and endothermic reactions: i.e., reactions which respectively tie up or liberate a certain amount of heat of combustion, thus causing results which deviate from those expected.

The composition of the ash, however, does not affect the value of coal very greatly, but in another way. Some components of ash act as fusing alloys, producing in use, so-called "running ashes," or a fused mass of clinker. Such clinker obstructs the free and uniform passage of air through the fuel bed, thus interfering with combustion, and impairing the efficiency. On account of this property of ash, a thorough study should be made in the laboratory of a sample of coal before purchase. Such a study entails, first burning a pulverized sample of the coal, and then heating the residue by means of a Bunsen burner, until it fuses. The temperature of this fusing point should be noted by means of a radiation pyrometer, and it should be higher than the temperature ordinarily found in a furnace.

The cost of handling and removing ashes plays no small part in forming our opinion as to the relative value of certain coals. We can determine the cost of handling if we know:—

1st—Per cent of ash in coal.

2nd—How completely the coal is burned.

3rd—How much unburned combustible is left in ashes.

Using Fig. 1 (a chart), we note at a glance that coal with 8 per cent ash, and 34 per cent combustible in refuse, will give as much residue to handle as coal with 10 per cent ash, having only 16 per cent combustible in the ash. In both these cases there will be 12 per cent residue to handle, i.e., 12 tons of ash to every 100 tons of coal. If coal with 10 per cent ash shows in residue 34 per cent combustible, then per cent of boiler refuse or "ash" to handle increases to 15 per cent. On the other hand, if coal with 8 per cent ash shows only 16 per cent of unburned combustible in the refuse, then the total ash to be removed will be only 9.5 per cent of the coal fired.

This amount of ash, and the cost of disposing of it, is not the only correction to be applied in comparing coal prices. The effect of sulphuric acid on the iron parts of the furnace, the destruction of the fire bricks by fused ashes, the burning out of grates with melted clinker, etc., all influence the cost of furnace and boiler repairs. These must be eliminated on an annual basis and allowance made for them in figuring the cost of coal used during the year.

Knowing this much of the peculiarities of that familiar stranger "Coal," we may now attempt to make ourselves immune from the caustic sarcasm of the U. S. Governmental experts by answering their thrust, "The farmers of the country show more business judgment in the purchase of fertilizer, than do many manufacturers in the purchase of coal, because the farmer demands a chemical analysis"—with the statement. "We at least know what the figures of a coal analysis mean, and know what to expect from coal of a given analysis."

The question of the wise selection of coal is not yet settled. The German saying—"hillig und schlect"—(cheap and punk) is almost invariably true in the case of coal. Yet it is not a criterion to go by. Freight rates from different localities might make the best "New River" or "Pocahontas" coal chaper than the worst kind of "Rhode Island" graphite coal.

We want coal to make steam, and this means that we want heat. The heat content of coal is determined by means of an instrument called a calorimeter. In a bomb calorimeter, a sample of coal is ignited by an electric spark in an atmosphere of pure oxygen under pressure. The coal burns completely, raising the temperature of the water, which surrounds the combustion chamber, and from this rise the heating value of the coal in B.t.u. per lb. can be computed.

Now you say, "This number of B.t.u. purchased in a dollar's worth of coal, is the true criterion of its value." I say it isn't. "Oh, yes," you say, "we shall correct for ash handling, ash and sulphur repair bills, and rain water sold at the price of coal." And still I say that the entire story is not told, because the B.t.u. was determined in a calorimeter and not in a furnace. You see some furnaces cannot completely utilize all the B.t.u., hence some of the heat we imagine we are getting is really wasted. For instance, volatile matters have high heating values, but we can't get the full benefit of them in a steel furnace. Also, coal which is inclined to coke will have imbedded in its clinker some combustible which is not available to make heat.

This tends to show that the only real and correct method of comparing the heating values of different kinds of coal is to burn them in our furnaces with our own load conditions prevailing. By this means we can find out the most economical method of steam generation

for each kind of coal, and then compare the cost of each making 1000 lb. of steam.

Referring to Fig. 2 (another chart), we will see how easily such a comparison can be made. From our calorimetric test we know the heating value of all the different kinds of coal we are going to burn, and since we also know the cost of each, we can easily figure their price per million B.t.u. in dollars. Lines representing this quantity are drawn diagonally across Fig. 2. The horizontal divisions represent the coal in cents for evaporating 1000 lb. of water from and at 212 deg. F., and the vertical divisions represent boiler and grate efficiencies in per cent.

Now let us suppose that one of our samples costs 8 cents per million B.t.u. and that we realize an efficiency of 60 per cent with it. We first find the intersection of the diagonal line for 8 cents with the efficiency line for 60 per cent. From this intersection we descend vertically and discover that with this fuel it costs us 13 cents to generate 1000 lb. of steam from and at 212. Similarly, with coal at 10 cents per million B.t.u. which gives us 75 per cent efficiency, we note that steam "from and at" costs 13 cents per 1000 lb. Which shall we use? To answer this question we shall have to look up other costs such as ash handling and repairs. In the example above we found two different priced coals which gave us the same cost per 1000 lb. of steam. If we look further we

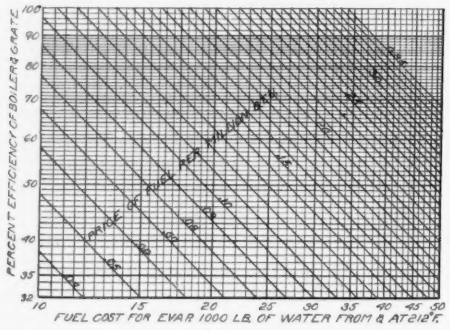


FIG. 2. COST OF FUEL FOR EVAPORATING WATER

can find other combinations. For instance, coal at 10 cents, with a boiler efficiency of 77 per cent gives us steam at 12.5 cents, while another coal at 9 cents with 60 per cent boiler efficiency comes to 14.5 cents for steam. Again, coal at 7 cents, with a boiler efficiency of 56 per cent makes steam at 12 cents while another coal at 10 cents with 69 per cent efficiency costs us 14 cents. These are enough samples to show the relation between these three very important members of our boiler room family.

"Is that all?" you ask sarcastically. I indignantly waive your attempt to ridicule the amount of trouble caused by such a trivial thing as coal. If your operating cost is 1/3c per kw.-hr. and you use 2½ lb. coal per kw.-hr. at $2.00 per ton, you are justified in spending 7 hr. out of every 10 watching your coal economy, and using the remaining 3 hr. to look after the other details of operation.

Now let us consider a few secondary conditions which influence the value and price of coal.

First, size. Anthracite coal is sold in the following sizes: broken, egg, nut, pea and buckwheat, while bituminous coal for power plant usage is either sold as "run of mine" and "screenings" or "slack." The smaller the fragments of coal the more compactly they will lie on the grates, thus making it more difficult to pass air through the fuel bed, and hence making it necessary to supply more than natural draft for any high rate of firing. A lot of people attracted by the low cost of this small sized coal did install expensive draft apparatus to burn it; but when this practice became general, the coal dealers either raised their price or stopped making it altogether.

Second, slate and bone. These are often specified in the contract as objectionable, because they are ash forming ingredients, but they do not require any special mention except as ash.

Third, weight. Railroad weight is often lower than the actual mine weight, for two reasons: First, evaporation of some of the moisture it contains; second, the loss of some of its gas. These same factors also cause coal stored open to the atmosphere to lose weight gradually.

This last leads up to a discussion of the problem of storing coal. For months after being mined, coal liberates a gas known as methane and absorbs oxygen. If the coal is stored in a closed bunker, the decrease of its heating value is not serious; but the liberated methane may cause an explosion.

When the coal is stored in the open air, the decrease in its heating value may vary anywhere from 1 to 5 per cent, depending on what kind of coal it is. Practically all of such a loss takes place within the first year, and is accompanied by considerable slacking. The danger from spontaneous combustion in stored coal varies directly as the percentage of moisture, sulphur and volatile matter.

Many experiments have been made in storing coal under water, in order to "preserve" its virtues; and although they have accomplished this purpose, and also eliminated the danger from spontaneous combustion, the stored coal retains from 5 to 15 per cent water which must be evaporated in the furnace, and on this account it is questionable whether it pays to use such storage for periods of less than one year.

For stored coal, the decrease in heating value, and the danger of self-ignition become greater as size of coal diminishes. Coal rich in volatile matter also suffers a greater loss in heating value, and is more liable to spontaneous combustion than the "run of mine" or anthracite. Storing coal under water is not very advisable for "R of M" coal, nor for coal low in volatile matter.

Probably the most important consideration against the storing of any great amount of coal for a long period are the interest on the investment and the usual high cost of reclaiming it.

It is unquestionably desirable to establish some simple method of determining the efficiency of coal in relation to its price and usefulness. Such a method has been worked out and may be illustrated as follows:

Let us assume that 1,000,000 B.t.u. in the shape of coal could be purchased for 5 cents, while the actual prices paid for two different kinds of coal are 6 and 8 cents per 1,000,000 B.t.u. The monetary efficiency in these two instances is 5/6 or 83.3 per cent for the first and 5/8 or 62.5 per cent for the second. Now the first coal, that at 6 cents, actually develops 75.6 per cent

furnace efficiency and 64.1 per cent boiler efficiency; while the second, that at 8 cents, shows 96.6 per cent furnace efficiency and 71.2 per cent boiler efficiency. Therefore, the relative "economy and efficiency" of those two kinds of coal are:—for the first at $1.85 per ton

$$\frac{83.3 \times 75.6 \times 64.1}{10{,}000} = 40.36 \text{ per cent}$$

and for the second at $2.10 per ton

$$\frac{62.5 \times 96.6 \times 71.2}{10{,}000} = 42.98 \text{ per cent}$$

From this comparison, we can see at a glance that although the second coal was both more expensive per ton and per 1,000,000 B.t.u. than the first coal, it really gives us about 6 per cent more economy.

Utilization of Pulverized Coal*

CHARACTERISTICS OF COALS THAT CAN BE USED SUCCESSFULLY IN PULVERIZED FORM; METHODS OF PREPARING AND HANDLING PULVERIZED COAL. BY H. G. BARNHURST

PRACTICALLY any coal can be burned in pulverized form with a proper furnace and burning equipment. Each application, however, must necessarily be governed by the quality of the fuel available in the district in which it is made. Generally speaking, however, the coals which would give the most satisfactory results would be those in which the ash content would be less than 10 per cent, the volatile averaging between 30 and 40 per cent and the fixed carbon between 40 and 50 per cent. The sulphur content should be low, although coal with a sulphur content running as high as 4½ to 5 per cent is being burned in pulverized form under boilers without any detrimental results. The ash should have a high melting point. These statements, however, are tentative, as most excellent results have been obtained from all sorts of coals differing widely from the ideal analysis stated.

It is very apparent that the development in this method of burning coal has brought coals from which heretofore very inefficient results have been obtained within reach of a great many consumers. For instance, from Texas to Edmonton, Alberta, the country is underlaid with various grades of lignites, low grades mineral coals with high moisture content and of such a nature that the ash would melt or flow down on the grates, thereby preventing the highest efficiency from being obtained. They are of such a nature that their use in gas producers is not very satisfactory, so that until the development and burning of these coals in pulverized form was an assured success these coals were not used in as large quantities as is now possible.

The largest deposits of lignite and mineral coals appear to be in the Northwest awaiting future development when proper means are at hand for obtaining the highest possible economy from their combustion, and the location of these large deposits will not be of great value to the districts in which they are located.

Around steel plants there are large quantities of waste fuel such as coke breeze. This fuel is being used to a certain extent on some forms of grates with forced draft, but it can be burned in pulverized form under boilers for the generating of power.

In the anthracite field there are large quantities of coal daily pumped back into the mines, which coal is a result of the washing and crushing operation for bringing the coal to commercial sizes. This silt or washery waste coal carries as high heat value normally as the coals which have been operated upon. The president of one of the large coal companies in the East told me that in the neighborhood of 8 to 10 million tons annually of this silt was allowed to be pumped back into the mines to fill up old workings.

A number of the coal companies are now carefully investigating the application of pulverized anthracite or low volatile coals with a view to using this waste coal in pulverized form so as to obtain power from its use, making available coal of higher grade for the market which they are firing at the present time.

Pulverized anthracite coal is now being burned in one or two installations, and the writer has personally burned pulverized anthracite coal in special forms of furnace.

PREPARING AND HANDLING OF PULVERIZED COAL

THE COAL as received is either in the form of slack, lump or run-of-mine and as it comes to the pulverizing plant it should be crushed so that it will go through approximately a 1-in. ring. A single roll coal crusher of approved make is usually the equipment. The coal should then be dried at low temperature to eliminate the moisture. Ordinarily it should be dried so it will not contain more than one per cent of moisture.

The drier is usually of the rotary type; that is, the coal is fed into an inclined shell mounted on rollers and is gradually passed through the drier by gravity. The firing chamber is usually located under the shell or so arranged that the products of combustion from the drier can be used not only to heat the shell of the drier but also to pass through it in order to obtain the greatest economy from the coal burned for the purpose of drying the coal.

The drier should be so arranged that the gases of combustion coming from the furnace do not come in contact with the coal being dried until they are reduced in temperature so they will not ignite the coal. The temperature of the coal being dried should only be sufficient to drive off the moisture; if the coal is allowed to become too hot, the volatile contents may be reduced, thereby sacrificing some of the heat value of the coal. This condition is readily obtainable, as practice has shown. A pyrometer should be installed to indicate to the operator the temperature to which the coal being dried, is exposed. An evaporation of from 5 to 7 lb. of moisture from the coal being dried can readily be obtained per lb. of coal burned on the grates in the drier. The amount of evaporation, however, naturally depends upon the quality of the coal being handled in the driers. The driers can also be fired with pulverized coal if desired.

*From a paper read at the Smoke Prevention Ass'n Convention.

A magnetic separator of some standard make is installed either before the crusher or after the drier so as to remove what may be called tramp iron which consists of pick points, railroad spikes, coupling pins, links, hammer heads, sledges, tobacco cans, nails, etc., all of which have been accumulated, either from the mines or in the crushing operation at the mines. The amount of iron per ton will vary in certain districts but it is an item of such importance that magnetic separators are being installed in every first class pulverized coal plant which is now being erected. The elimination of this iron naturally improves the pulverizing and conveying operation and prevents breaks and losses due to intermittent operation and wear and tear of the machinery.

Coal as it is passed through a modern pulverizing plant should be elevated and conveyed in dust-tight equipment. After crushing, the coal should be elevated to bins above the driers. These bins should be of ample capacity and arranged with variable speed feeding mechanism so that the driers at all times will have uniform feed. This is very important so that the moisture content will be reduced uniformly and thereby allow close furnace regulation where the fuel is burned. Leaving the drier, the coal is elevated and discharged into storage bins above the pulverizers. The storage bins above the pulverizers should be of such capacity that the pulverizing machinery will at all times receive ample feed to prevent them from running empty. All storage bins should be of dust-tight construction, and equipped with deep hopper bottoms so that the coal is constantly in motion while being drawn off. It is in coal lying dormant or stationary that spontaneous combustion or smouldering action is generated, particularly so where coals are under pressure.

The danger of spontaneous combustion of pulverized coal has been greatly exaggerated. It has been considered that the matter of pulverization increases this danger, but it is a matter of fact that practically nothing more than the usual ordinary precautions taken with all fuels are necessary to guard against it. The mere factor of pulverization is not of any unusual importance as is readily shown in the commercial production of lamp-black, which is handled very much like pulverized coal, without bad results. This lamp-black is probably 30 to 50 times finer than the average size particles found in commercial pulverized coal.

In the lamp-black industry, by the way, it has been found that only partially filling the barrels when shipping gave better results than when packing the material up to the top.

Spontaneous combustion is simply the absorption of oxygen. If this absorption becomes too rapid, heat will be generated and incandescent combustion will result. The presence of pyrites tends to oxidation to a rapid extent in any fuel, with the probable disengagement of light carburetted hydrogen, and spontaneous combustion results. In the case of lamp-black, this condition of course is removed, as the lamp-black contains practically no sulphur, certainly not in the form of pyrites.

Pulverizers of ample capacity to take care of the fuel requirements should be of such a nature that their cost of operation, attendance, power and repairs are at a minimum. A first class pulverizer should be one which can operate if necessary over the period of from one to three months continuously without shutting down even for oiling. The pulverizers should also be of a type that normally delivers a product containing the highest percentage of impalpable powder. Coal should be pulverized so that ordinarily 95 per cent will pass a 100 per cent mesh sieve. The machinery in the pulverized coal plant where possible should be driven by electric motors. The drives should be standardized and the motors interchangeable. Back geared motors are successfully used in a great many installations, and the pulverizers can be driven either by motors with belt drives or gear driven with a flexible coupling between motor and pulverizer.

Dust collectors are sometimes installed in connection with driers. This dust is formed by the action of the coal passing through the drier; as the coal falls down, a certain amount is ground to dust and this dust, being in suspension, is carried along by the air currents through the drier and the dust collector will recover it.

The adoption of pulverized coal for any particular operation naturally depends on the cost of preparation or handling which is a charge in addition to the fuel itself, which charge, however, in a great many cases is less than that where lump coal is used. The power required in a first class pulverized coal plant per net ton of coal handled is in the neighborhood of 17 hp.-hr., per ton produced. This includes the power for crushing, drying, elevating and conveying and delivering the pulverized coal to the conveyors, leading to the point of use. The repairs vary slightly with the quality of the coal being handled, but generally speaking the repair costs for the pulverizing plant should be somewhere between five and seven cents per net ton of coal handled.

The drier fuel is practically a constant, as the amount required per ton of coal dried with a given moisture content with standard driers will not vary very much.

In the Lehigh Valley district where the coals carry from five to ten per cent of moisture as received, 25 to 35 lb. of coal are required to be burned on the grates per ton of coal dried. The cost of this coal is naturally based on the cost of the coal as received. The great variable in the cost of preparation in pulverizing coal then comes down to the labor item. The labor varies indirectly with the quantity of coal handled and the time or continuity of operation in the pulverizing plant. In other words, the question of labor cost is one directly affected by the equipment installed. One man can handle quite a number of machines, so that in making up an estimate on the probable cost of pulverizing coal careful consideration should be given to these statements.

Generally speaking, coal in fairly large quantities from 50 to 100 tons and upwards can be pulverized and delivered to the furnace at a cost from 20 to 50 cents per ton depending upon the quantity handled. Nothing has been said, however, as to interest and depreciation, taxes, overhead and other burdens entering into the ultimate cost of preparation, as those are items which have to be considered in each specific case.

The subject of pulverized coal handling from the pulverizers to the point of use is important. The application of any particular method depends upon the

distance to which coal must be transported as well as the quantity to be handled per hour. The general practice in plants where pulverized coal has been used for a number of years and in plants where the capacity would be from about 50 tons per day upwards is the use of screw conveyors for conveying the coal. These screw or spiral conveyors are mounted in dust-tight troughs. The gudgeon forming the connection between the different sections of the conveyor runs in chilled bearings and when properly installed its upkeep is very low. They do not require much attention, and the bearings last for years, the coal itself acting as a sort of lubricant. Coal after being pulverized weighs only from 32 to 38 lb. per cubic foot and is permeated with air flowing along the conveyors like a fluid. The horsepower consumption for distribution with this system is low, and when properly installed this system is dustless.

There are other means of conveying pulverized coal, such as carrying it in suspension. More power, however, is required for furnishing air to carry the coal in suspension and at such a velocity to prevent its building up in the blast pipes, than is used where screw conveyors are installed.

The necessity of closing up every leak and the possibility of moisture affecting accumulations in the transmission lines make a system of this kind usually expensive to operate.

Another method now being developed is the conveying of pulverized coal through pipes by means of compressed air. With this system the coal enters the pipes in charges, compressed air being used as a means of propulsion. Relief valves and cyclone collectors naturally must be installed so as to relieve the pressure after the charge has been delivered to the receiving point. This system is installed in one or two plants, but its success and operation have not been sufficiently apparent to warrant its installation in plants where a fairly large quantity of coal is handled daily, or for a short distance. This system should be considered where coal is to be transported a long distance.

At the railway shops of the Missouri, Kansas and Texas R. R. for over a year pulverized coal has been in use under their boilers with very satisfactory results. These boilers have been operating continuously day and night and for short periods daily at from 150 per cent to 180 per cent rating. Practically no repairs to furnace arches or walls have been made during the year's operation. Absolute *smokeless operation* has been accomplished. The flue gas analysis during some of the recent tests has varied from 15 to 17 per cent. Coals carrying on an average of from 10 to 22 per cent of ash with a moisture content varying up to 17 per cent as fired are being burned satisfactorily. The furnace efficiency has been very nearly perfect; three tests made in June showed a furnace efficiency of 98.4 per cent, 98.6 per cent and 99.4 per cent.

Measurement of Air and Gases by the Pitot Tube

EXPLANATION OF THE USE OF THE PITOT TUBE AND TABLES TO SIMPLIFY CALCULATIONS. BY A. H. ANDERSON*

THE pitot tube is now generally understood by engineers, but its application has been restricted to research.

Perhaps the reason the pitot tube has not received the attention it deserves in the industrial trades, for metering air and gas, is because recording instruments are available. Recording meters are desirable, but there is still a wide field in which an inexpensive device must be used. For instance, in distributing costs of gas or air among various departments, an indicating pitot tube may be placed in each branch and practically the same information obtained as with an elaborate instrument. In the air supply duct to a foundry cupola or a set of forges, the proper quantity of air can be gaged with a pitot tube and maintained during the period of operation.

The pitot tube is easily changed from place to place, and the pressure or velocity of air may be gaged at different points along an exhaust line where the size of duct changes with the number of branches admitted.

The indications of the pitot tube are made readily available by the use of the tables given in this article by means of which calculations are avoided. They apply to air at approximately atmospheric pressures and also to gases of various densities, such as illuminating, coke oven, blast furnace and natural gas. In order that these tables may be applied directly, the coefficient of the pitot tube must be 1.00. If the coefficient of the pitot tube is 0.8, then the tabular value for velocity must be multiplied by 0.8. The pitot tube in Fig. 1 has a coefficient of 1.00.

An illustration of the proper method of connecting a pitot tube to the indicating differential gages is shown in Fig. 1. The liquid used in the gages is a mineral oil of 0.834 specific gravity and the color is red to make it conspicuous. The scale attached to the gage is graduated to read in inches of water. The dynamic (or bent) tube is in communication with the left-hand end of the upper gage. The static (or beveled) tube is in communication with the right-hand end of the upper gage and the left-hand end of the lower gage. Therefore, the upper gage indicates the "velocity pressure" and the lower gage indicates the static pressure.

The velocity corresponding to the "velocity pressure" may now be determined by reference to the tables. Temperature, static pressure and humidity affect the velocity, but within certain limits the static pressure and humidity may be neglected.

Table I, shows the velocities of air at 80 deg. F., corresponding to various "velocity pressure" readings, in inches of water.

Table II, shows the coefficient by which the velocities in Table I may be multiplied when the air is of any other temperature than 80 deg. F. Coefficients are also given in this table for gases of various densities.

*Associate Professor of Experimental Engineering of Armour Institute of Technology.

In certain cases where the pitot tube is placed in a long straight pipe, it may be assumed eddy currents are absent, and the tip of the pitot tube may be located at a distance from the center equal to 0.8 of the actual radius, in order to obtain average results. In most cases there are conditions which deflect the air currents in the pipe, and the maximum velocity is found at one side of the center. Under these conditions, it is necessary for accurate results to determine the average velocity by making a traverse of the pipe with the pitot tube. This can be done in the following manner: Determine the actual radius of the round pipe and make a series of pitot tube observations at intervals from the center to

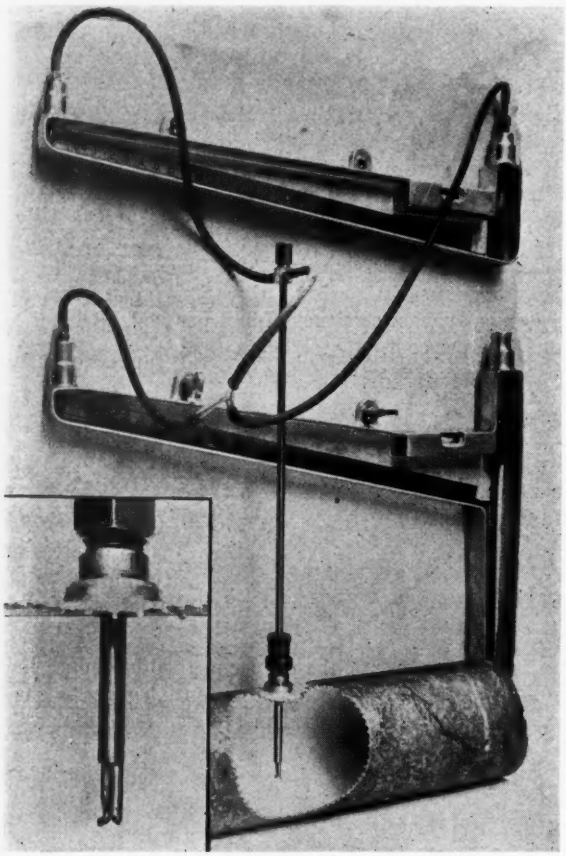


FIG. 1. DETAIL OF PITOT TUBE AND METHOD OF ATTACHMENT TO PIPE

the wall. The intervals between the readings are determined by the equation.

$$R = \frac{r}{\sqrt{N}} \sqrt{(2a-1)}$$

Where R = distance of various positions from center of pipe, inches.
r = radius of pipe, inches.
N = number of readings desired from wall to wall.
a = order of readings from center.

The pitot tube is now located in turn at the positions as determined above, first, on one side of the center, and then on the other side. The velocities corresponding to the 10 velocity pressures are taken from Table I, and the arithmetical average determined.

TABLE I. AIR VELOCITIES CORRESPONDING TO VARIOUS VELOCITY PRESSURE READINGS

Air at 80 deg. fah.; 100% humidity; 29.5 in. Barometer.							
Vel. Press. Inches.	Ft. per min.	Vel. press. inches	Ft. per min	Vel. press. inches	Ft. per min	Vel. press inches	Ft. per min
.01	409	.50	2,890	.99	4,070	1.48	4,976
.02	579	.51	2,920	1.00	4,090	1.49	4,993
.03	710	.52	2,950	1.01	4,110	1.50	5,010
.04	818	.53	2,980	1.02	4,130	1.60	5,180
.05	914	.54	3,000	1.03	4,150	1.70	5,330
.06	1,000	.55	3,030	1.04	4,170	1.80	5,490
.07	1,080	.56	3,060	1.05	4,190	1.90	5,640
.08	1,155	.57	3,090	1.06	4,210	2.00	5,790
.09	1,227	.58	3,115	1.07	4,230	2.10	5,930
.10	1,295	.59	3,140	1.08	4,250	2.20	6,080
.11	1,355	.60	3,170	1.09	4,270	2.30	6,210
.12	1,418	.61	3,200	1.10	4,290	2.40	6,330
.13	1,475	.62	3,225	1.11	4,308	2.50	6,480
.14	1,530	.63	3,250	1 12	4,327	2.60	6,600
.15	1,585	.64	3,275	1.13	4,345	2.70	6,720
.16	1,635	.65	3,300	1,14	4,364	2.80	6,850
.17	1,690	.66	3,325	1,15	4,382	2.90	6,970
.18	1,735	.67	3,350	1,16	4,401	3.00	7,090
.19	1,785	.68	3,375	1,17	4,419	3.10	7,200
.20	1,830	.69	3,400	1,18	4,438	3.20	7,320
.21	1,875	.70	3,425	1,19	4,456	3.30	7,430
.22	1,920	.71	3,450	1,20	4,475	3.40	7,540
.23	1,960	.72	3,475	1,21	4,493	3.50	7,660
.24	2,005	.73	3,500	1,22	4,512	3.60	7,760
.25	2,050	.74	3,525	1,23	4,530	3.70	7,870
.26	2,090	.75	3,550	1,24	4,549	3.80	7,970
.27	2,125	.76	3,570	1,25	4,567	3.90	8,070
.28	2,160	.77	3,590	1,26	4,586	4.00	8,180
.29	2,200	.78	3,615	1,27	4,604	4.10	8,280
.30	2,240	.79	3,640	1,28	4,623	4.20	8,400
.31	2,275	.80	3,660	1,29	4,641	4.30	8,480
.32	2,310	.81	3,680	1,30	4,660	4.40	8,580
.33	2,350	.82	3,700	1.31	4,678	4.50	8,670
.34	2,390	.83	3,720	1.32	4,696	4.60	8,770
.35	2,420	.84	3,740	1.33	4,714	4.70	8,870
.36	2,455	.85	3,765	1.34	4,732	4.80	8,970
.37	2,485	.86	3,790	1.35	4,750	4.90	9,060
.38	2,520	.87	3,810	1.36	4,768	5.00	9.140
.39	2,550	.88	3,835	1.37	4,786		
.40	2,590	.89	3,860	1.38	4,804		
.41	2,620	.90	3,880	1.39	4,822		
.42	2,650	.91	3,905	1.40	4,840		
.43	2,680	.92	3,925	1.41	4,857		
.44	2,710	.93	3,946	1.42	4,874		
.45	2,740	.94	3,967	1.43	4,891		
.46	2,770	.95	3,988	1.44	4,908		
.47	2,800	.96	4,008	1.45	4,925		
.48	2,830	.97	4,029	1.46	4,942		
.49	2,855	.98	4,050	1.47	4,959		

As an illustration, assume a round duct 10 in. diameter, the number of observations from wall to wall to be 10. In this case, "r" = 5 in. "N" = 10; "a" assumes

TABLE II. VELOCITY COEFFICIENTS FOR VARIOUS TEMPERATURES

		GAS Lb. per cu. ft. at 80 deg.			
Deg. Fahr.	Air	.05	.055	.06	.065
50	0.972	1.160	1.111	1.060	1.020
60	0.980	1.170	1.120	1.070	1.030
70	0.990	1.180	1.130	1.080	1.040
80	1.000	1.200	1.140	1.090	1.050
90	1.010	1.210	1.150	1.100	1.060
100	1.025	1.225	1.170	1.115	1.075
110	1.038	1.245	1.185	1.130	1.090
120	1.049	1.255	1.195	1.143	1.100
130	1.060	1.270	1.210	1.155	1.111

values from 1 to 5. The values of "R" on one side of the center resulting from the substitution in the equation are as follows:

	Distance from center, inches
R_1	1.58
R_2	2.73
R_3	3.53
R_4	4.18
R_5	4.74

The positions on the other side of the center are duplicates of those given below. Actual velocity pressures and velocities from a test of a 10-in. pipe are shown in Table III, the corresponding curve being given in Fig. 2.

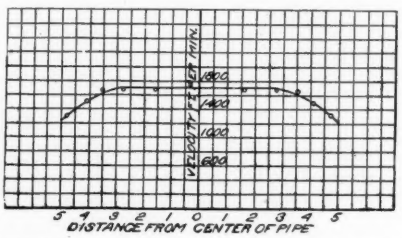


FIG. 2. VARIATION IN AIR VELOCITY FOUND IN TRAVERSE OF A 10-IN. ROUND PIPE

The pitot tube may now be permanently located in the pipe in either of the two ways described:

(1) Locate the tip of the pitot tube at the proper distance from the center of the pipe to obtain average reading; or

(2) Locate the tip of the pitot tube at the center of the pipe and multiply the indicated velocity by the ratio of the average to the center velocity.

Method 1. Figure 2 gives a curve showing the variation of velocity across one diameter of a round pipe. This curve is drawn from the test data in Table III. The average velocity is 1550 ft. per min., and the maximum velocity (or velocity at the center), is 1650 ft. per min. The average velocity is found at a distance of 4.2 in.

TABLE III. RESULTS OF TEST OF A 10-IN. PIPE

Distance from wall, in.	Distance from center, in.	Velocity pressure, in.	Velocity ft. per min.
0.27	4.73	0.105	1310
0.83	4.17	0.125	1450
1.50	3.50	0.145	1550
2.27	2.73	0.160	1630
3.42	1.58	0.165	1650
6.58	1.58	0.165	1650
7.73	2.73	0.160	1630
8.50	3.50	0.145	1550
9.17	4.17	0.125	1450
9.73	4.73	0.105	1310
		AVERAGE	1550

from the center, and if the tip of the pitot tube is located at that point the readings obtained from the gages give average results.

Method 2. The ratio of average velocity to maximum velocity is $\frac{1550}{1650} = 0.94$. If the tip of the pitot tube is located at the center of the pipe the indications of the gage give the velocity at the center, which multiplied by the ratio gives the average velocity.

The foregoing methods involve preliminary work in order to obtain the proper setting at the pitot tube; but this must be done in any event, whether the apparatus is of the inexpensive type or of the most elaborate design.

The method computing the proper intervals between pitot tube readings in the average velocity determination may be replaced by the graphical method which is shown in Fig. 3. The large circle represents the round pipe. Upon the radius is constructed a semicircle. The radius of the large circle is divided into as many equal dividends as there are to be pitot tube readings. Erect perpendiculars from each point and through the intersection of each perpendicular, and the circumference of the semi-circle construct circles with the same center as the large circle. The radius of the inner ring is OJ', while the radius of the mid-position for the pitot tube is OK'. The construction of Fig. 3 is for the case of the 10-in. pipe mentioned earlier in this article. To obtain a complete traverse of a diameter of the pipe, set the pitot tube at each of the radii proceeding from one wall to the other.

It will be observed that great stress has been laid on the importance of obtaining accurate values for average

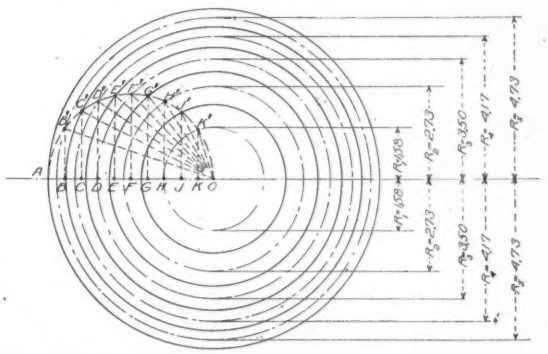
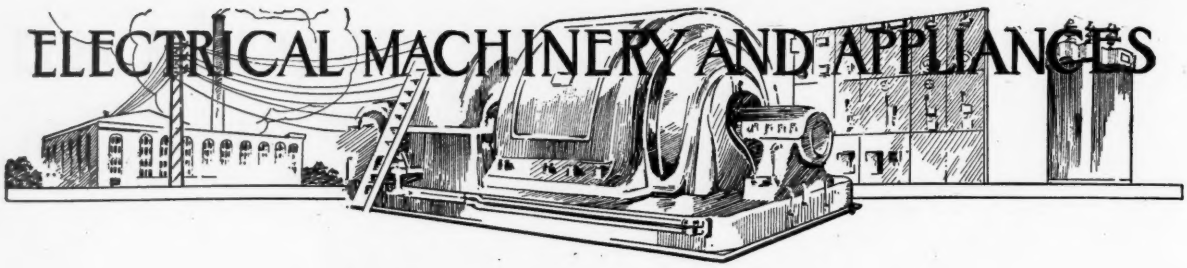


FIG. 3. GRAPHICAL METHOD OF COMPUTING AVERAGE VELOCITY

velocity. This is necessary because local conditions distort the air currents in a pipe and each individual application must be examined by itself.

The internal diameter of the pipe must be carefully measured and the cross-sectional area calculated in square feet. The product of the area and the average velocity is the volume of gas or air moved per minute.

THE FIRE WASTE in the United States is appalling, being considerably more than $200,000,000 yearly. Some fires have their origin in conditions that could not be foreseen, but by far the greater part could have been avoided by taking the simple precautions that experience has shown to be effective. When one visits a manufacturing plant consisting of wooden buildings without sprinkler equipment or the more primitive fire-fighting apparatus, and sees waste piled against wooden partitions, floors littered with excelsior, work-benches set against the walls with greasy boxes and litter piled beneath, he feels that the foolkiller is on his way and will arrive sooner or later. A clean and orderly shop not only favors production, but insures against accidents and fires. The insurance costs comparatively little and is worth many times the price.



Building Conduit Lines

METHODS EMPLOYED TO OVERCOME DIFFICULTIES ENCOUTERED DUE TO MARSHY SOILS. BY HENRY A. COZZENS, JR.

IN ORDER to obtain proper docking facilities and sufficient water for condensing purposes, it has frequently become quite essential to locate power plants on the marshy shores of a river. If the station has a large capacity, the pole lines leading therefrom are

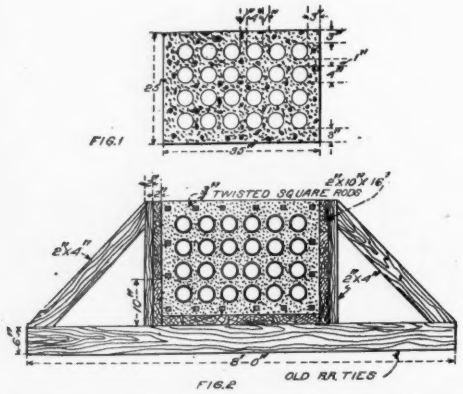


FIG. 1. CROSS-SECTION OF DUCT LINE USED IN ORDINARY STREET WORK

FIG. 2. METHOD OF SUPPORTING AND BRACING DUCT LINE LAID IN MARSHY SOIL

heavily loaded with transmission lines. In case of severe lightning storms or heavy sleet deposits during the winter months, the continuous operation of the lines is often jeopardized and to decrease the liability of interruption due to possible overhead line failures, a number of utility companies have installed underground conduit systems and have abandoned overhead construction. On account of the low bearing qualities of the soil, the matter of conduit line construction has become somewhat of a problem.

When a conduit line consisting of fiber duct surrounded by concrete is placed in the average street, the form of construction employed is similar to that shown in Fig. 1. One inch of the concrete is placed between the ducts and a 3-in. envelope of concrete surrounds the structure. This, however, has not sufficient strength to permit its use in marshy land.

A form of construction which possesses the advantages of simplicity, strength and cheapness for use in marshy land is shown in Fig. 2. The trench is first dug of such depth as required for the number of ducts to be installed with due allowance made for the proper cover. The width of the trench is such that old railroad ties may be used as a foundation. These are placed about 6 in. apart and the spaces between filled with ashes thoroughly tamped.

Figure 3 shows the trench being dug and the foundation of ties and ashes being laid. It also illustrates the manner in which the conduit line passes under another duct line temporarily supported during the construction. The completed foundation is shown in Fig. 4 ready to receive the wooden trough.

The purpose of the wooden trough is to retain the concrete until it has set. In the construction of duct lines in a city street, where the soil remains in place, no trough is required as the concrete is confined by the sides of the trench. In this instance if the railroad ties were cut the width of the completed duct line, it is probable that no trough would be needed as the soil

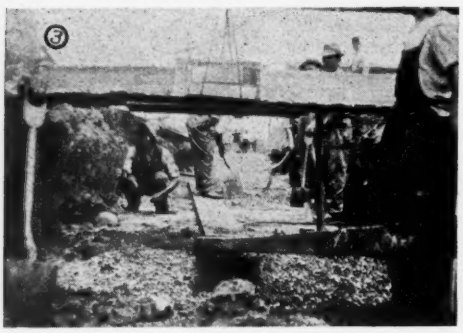


FIG. 3. EXCAVATING AND PLACING FOUNDATION OF TIES AND ASHES

FIG. 4. COMPLETED FOUNDATION

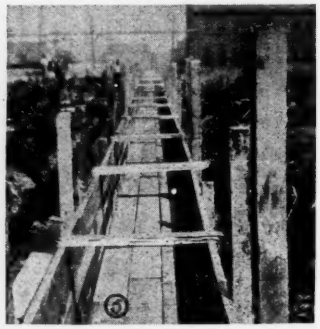


FIG. 5. WOODEN FORM READY TO RECEIVE CONCRETE

was of sufficient strength to remain in place at the sides of the trench until the concrete had set. As the conduit line was heavy, however, it seemed advisable to leave the ties 8 ft. long and thereby gain additional bearing surface at the sides and to construct the trough in order to retain the concrete as it was poured. The lumber used for the sides of the trough could be removed and used again as the work advanced. The completed trough ready to receive the concrete and ducts is shown in Fig 5.

The side braces for the trough were 2 by 4 by 4-in. timber and were placed every 16 ft. which was the length of the 2 by 10-in. planking used as the sides and base.

The concrete envelope around the duct line was reinforced with ¾-in. twisted square iron rods as the concrete was poured and the ducts laid. The spacing of the ducts was the same as in city streets.

After the concrete had set, the wood planking at the sides was removed and the soil replaced at both sides and top. The same construction may be used for the manholes, although it is often wise to drive a few short piles in addition to making the foundation of railroad ties and ashes.

This method of constructing heavy conduit lines has proved entirely successful after many years of service.

Training Operators of Induction Motors

By D. R. Shearer.

TO ONE knowing the simple ruggedness and operating characteristics of modern induction motors especially those of the polyphase type, it would appear that there is nothing to be taught the operators of such machines that would add to the efficiency and effectiveness of alternating-current electric drive. Such, however, does not appear to be the case when men having no fundamental knowledge of electricity are called upon to operate machinery driven by induction motors. There are several methods of starting, stopping and operating which are essentially bad for the motor and for the compensators or starting boxes and it is these methods which are commonly used by the untrained men handling such equipment.

Recently, a test was made in an industrial plant electrically driven by 28 3-phase motors of sizes varying from 3 to 150 hp. each, to determine just what effect on efficiency of operation and upkeep expense a brief instruction to each operator would have. The results were very favorable indeed, especially with regard to the cost of repairs, for not only was better service secured but the number of repairs was cut down materially.

The following list of rules were printed and posted at each motor compensator and the operators were told briefly the reasons for the different rules and why a strict compliance with those rules would save much trouble.

1—Pull (or push) the lever to starting position; hold until the motor comes up to speed, then throw into running position and see that no-voltage release catches and holds lever firmly. Do not under any conditions throw lever into running position until motor is practically up to speed.

2—If the motor does not start promptly when the lever is thrown into running position, examine the machine which it drives as something may be stuck or binding. If the machine appears all right, see if the fuses are blown or distribution switch is out. If the motor still refuses to start call the machinist or electrician at once and let the motor alone.

3—Do not try to start or run the motor on two fuses, as it will either burn out the remaining fuses or injure the motor.

4—If the machine stalls and motor does not trip out, throw it off at once, as a stalled motor is practically a short circuit.

5—In throwing in friction clutches, do so gradually and only after the motor is up to speed and in the running position, as a sudden jerk may pull the motor out of step or twist off a shaft.

6—Do not start operating any machine until the motor is running freely at normal speed.

7—Keep the bearings oiled and see that rings are turning freely.

8—If bearings wear down until the rotor rubs the starter, stop the motor until it is repaired.

9—In starting a heavily loaded motor, do not jerk the compensator lever backward and forward, as this speedily burns up the contacts, but hold the lever steady until speed is attained.

10—If no-voltage release fails to hold, do not prop the lever with a stick but see if the relays are stuck.

11—If anything appears wrong with a motor, call the electrician or machinist at once and do not experiment.

12—Let one man only make all the repairs and adjustments. That is his business; yours is to operate the machine which the motor drives.

Sales Work to Reduce a Power Peak

The sales force of a Seattle electric light company was recently sent out to interview power consumers using over 50 hp., and secure other cooperation in smoothing out a critical peak in the power load. This peak was a daily rise in the power load for about one month in the latter part of the year, recurring annually. It had become the governing factor in determining capacities of the company's power stations. This year the problem promised to be unusually acute by reason of new industries devoted to war purposes which had been added to the load. The critical interval was between 4:30 and 7 p. m. each day. Out of the first 266 consumers visited by the salesmen, says the Electrical World, only two were unable to co-operate by shifting their power requirements during those hours. Some of them did this by earlier closing, 24 concerns taking 2600 kw. off the peak. Street car requirements were reduced by arrangements with factories and stores whereby employes were dismissed in sections at intervals. In some cases, detailed study of a given concern's current consumption showed that it was more desirable to furnish energy for operation of plant during the peak period than to close down and release employes as energy requirements for street cars to carry the latter home added more to the peak than was saved by closing the factory. This campaign resulted in marked economies, but called for most intelligent interpretation of industrial current consumption and close teamwork by the sales force.

The Absorption Refrigerating Machine

ACTION OF AQUA-AMMONIA; PARTS OF THE SYSTEM AND THEIR FUNCTIONS. BY W. L. MYER

FOR the benefit of engineers who know little of the absorption refrigerating machine but have a knowledge of the compression machine—the absorption system uses aqua, aqua-ammonia, or "agua," as a medium for transferring ammonia gas from low-pressure side to the high-pressure side by means of a pump.

Water has a very close affinity for ammonia. One volume of water will absorb approximately 700 volumes of ammonia at low temperature, and 100 volumes when raised to temperature of steam. When pressure is applied to gas the concentration is increased. By the above, it can be seen that the cooler the gas and the higher the pressure on it and the water the higher the concentration and, vice versa, the higher the temperature and the lower the pressure, the lower the concentration. The higher the concentration of aqua the lower the specific gravity, because the ammonia absorbed is lighter than water.

The essential parts of an absorption machine besides the condenser and evaporating surface used with compression machines, would be a container called an absorber to bring the ammonia gas and water together on low pressure side; a container on the high pressure side called a generator to hold the solution of aqua-ammonia and a means of applying heat to raise the temperature and drive off a large portion of the ammonia gas held in solution by the aqua. Another essential part is the aqua-ammonia pump to move the aqua-ammonia from the low pressure to the high pressure side. This pump being the only reciprocating part.

The ammonia condensing and evaporating surface are the same as for any compression refrigeration machine. The rest of the absorption machine is used mainly to raise efficiency.

The generator, as commonly called by manufacturers, is, in reality, a still. It must be built to withstand the condensing pressure of ammonia which will run from 100 to 200 lb. per sq. inch. Naturally the shell will take a cylindrical shape for strength. The heads are built and arranged for steam coil inlet and outlet. The number of coils according to size of units and service required.

Heat of the steam raises the temperature of the aqua-ammonia and forces a certain amount of the ammonia gas out of solution, the amount depending upon the temperature and pressure. A certain temperature and pressure will have certain concentration of ammonia gas in water. As the heat drives off the gas the density or specific gravity will increase and the liquid will fall to the bottom of the generator shell where a pipe is tapped off called a weak aqua-ammonia line to carry the weak liquor to the exchanger. The ammonia gas as formed is usually piped to an analyzer—some manufacturers have done away with the analyzer, especially on low pressure steam machines.

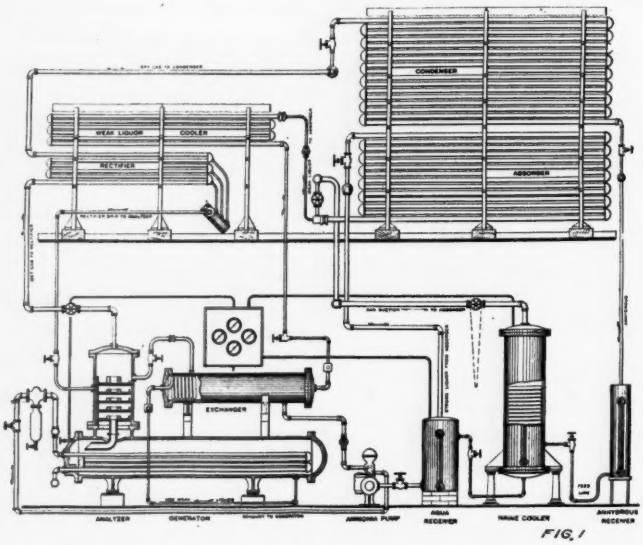


FIG. 1. ABSORPTION SYSTEM WITH ANALYZER AND ATMOSPHERIC TYPE CONDENSER, ABSORBER AND COOLER

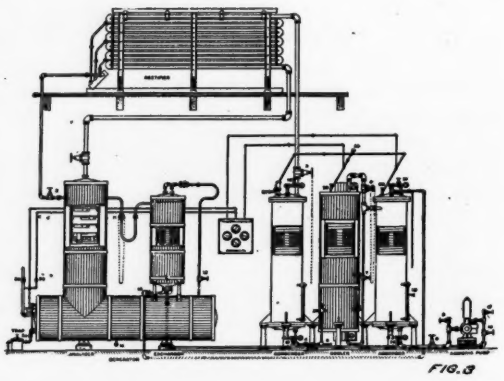


FIG. 3. SHELL TYPE APPARATUS FOR ARSORPTION SYSTEM WITH SPIRAL COOLING COILS

This analyzer can be compared to a boiler feed water heater. Aqua-ammonia going to the generator comes in direct contact with the superheated ammonia gas coming from the generator. Whereby the warm aqua-ammonia exchanges heat with the superheated gas condensing a certain per cent of water vapor which is bound to rise with the ammonia gas in the generator. This exchange of heat also frees a certain per cent of gas from the aqua-ammonia to join the other gas flow, while the aqua-ammonia flows by gravity to the generator. The gas is piped to a cooling arrangement called a rectifier or dehydrator.

The word rectify means to make pure and dehydrate to make dry or eliminate moisture. By this definition,

it can be seen that the function of the rectifier is to eliminate the moisture as much as possible. To do this, the temperature of superheated gas is brought down to 20 or 30 deg. F. of superheat above the condensing temperature corresponding to the pressure. By bringing this temperature down, the water vapor will condense and is trapped and led back to the generator. To bring this temperature down, the gas is put through submerged atmospheric or double pipe coils, having the flow of the water regulated to obtain the above temperature. The dry ammonia gas called anhydrous ammonia is led to the ammonia condensers to be liquefied.

Condensers are built on the same order as compression machine condensers, and serve the same purpose. The liquid ammonia is led to a liquid receiver, thence to the evaporating surface.

A point on the evaporating surface which is not understood by many engineers, is that if the water is allowed to accumulate on this surface by the improper care of the rectifier or defects in installation, the evaporating temperature of the ammonia will be raised considerably and also the water chokes up the coils.

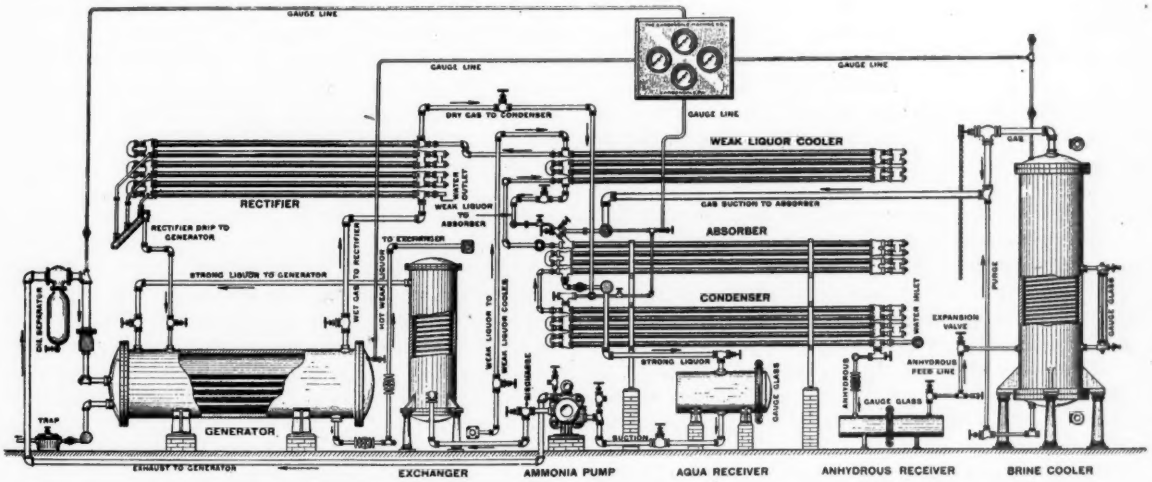


FIG. 2. ABSORPTION SYSTEM WITHOUT ANALYZER; ABSORBER, CONDENSER AND COOLERS OF DOUBLE-PIPE TYPE

Anhydrous ammonia evaporated on the evaporating surface is now led to the absorber. This is built in many types, each having for its function to bring the ammonia gas and aqua in closest contact so that the aqua will be as fully saturated with ammonia gas as the conditions of pressure and temperature will permit. Another point to be considered is that when a pound of aqua absorbs a quantity of ammonia gas a certain amount of heat is generated within the liquid. To make aqua an efficient carrier of ammonia gas, cooling water is applied to the absorber to carry off the heat of absorption. Absorbers are built in shell cylindrical form with spiral coils or straight tubes for cooling water surface. Another type is built double pipe with aqua injected into the gas space at the entrance to the coil. The coil surface is used to cool the resultant mixture.

The highly saturated aqua is now called strong aqua which is pumped by the aqua-ammonia pump to the exchanger where the cool strong aqua exchanges heat with the hot weak aqua coming from the bottom of the generator. Exchangers are built in two forms, shell and coil, and double pipe. After an exchange of heat where the temperatures are nearly equalized, the strong aqua is discharged into the analyzer on machines having that unit, or directly to generator. The weak aqua after being cooled considerably at the exchangers is led to a weak aqua cooler, built atmospheric or double pipe coils. The aqua is cooled to as near the temperature of the available cooling water as possible before passing to the absorber. The weak aqua is throttled to take care of the amount of ammonia gas necessary and within the capacity of absorber and pump. The cycle of operation is complete, and acts continuously.

Peat for Power

THE FUEL SITUATION has directed attention to the possibility of burning peat, of which there are large areas throughout the United States and Canada, especially in regions remote from coal fields. The best development along this line is for industrial fuel rather than domestic purposes. Peat is well adapted for use in gas producers or for burning in powdered form. It must be collected, dried, and powdered by machinery, and the main problem is drying without the use of artificial heat except such as may be available from other processes. In its natural state peat contains about 90 per cent water. This can not be extracted by any mechanical means as yet devised. For gas-producer use, peat should contain not more than 30 to 35 per cent moisture, and for powdered fuel not over 15 per cent. Drying can be done by storage several months, so that the sun and air may prepare the material, finishing with waste artificial heat. The Canadian Government has demonstrated the value of peat in gas producers for power and other purposes, while powdered peat has been used for some time in Europe with high efficiency. It is estimated that the cost of a ton of our dried peat in this country will range from $3.50 to $4 in quantities of 5000 tons, making it worth investigation as power fuel where coal costs $8 a ton or more, and peat can be secured without much expense for transportation.

Babbit and Its Application

Composition, Methods of Pouring, Finishing, and Its Use in Repair Work. By T. J. Johnson

AMONG the metals used in the construction of bearings are cast iron, steel, gun metal, phosphor-bronze and white alloys; while numerous other materials, many of which are patented, such as tempered copper, coiled steel wire, aluminum, lignum-vitæ and other hard woods, compressed paper, stone and glass compositions, have also been used for this purpose with more or less success.

White metal alloys are solid materials composed of 2 or more metals, such as aluminum, zinc, nickel, tin, lead, copper, antimony and bismuth, in varying quantities and fluxed and alloyed in various ways. These alloys have great advantages over the other materials; as the friction is low they are easily worked and can be melted in an ordinary iron ladle so that no special equipment is required for the replacement of worn bearings; they are long wearing, they tend to reduce shock on machines as well as deaden noise; they can be readily provided with grooves for lubrication and are easily fitted to a uniform bearing.

A fault of all white metal alloys is their liability to melt and run should accidental overheating take place, but although other materials do not melt and flow when overheated, like heating will cause equally disastrous results.

In 1839, a patent was granted to Isaac Babbit for a special type of bearing enclosing a soft metal alloy. This alloy, composed of tin 24 lb., antimony 8 lb., and copper, 4 lb., to each pound of which was subsequently added 2 lb. more of tin, gave a metal composed of 88.88 per cent tin, 7.4 per cent antimony, and 3.7 per cent copper. Metals of this type which approximate 90 per cent of tin in their composition, are now called U. S. Government Standard or A-1 babbit, and all other white metal alloys on the market for use in bearings, no matter what their composition may be, are called babbit.

Babbits made up according to nearly 300 different formulas are at present on the market and it would be of great benefit to the users of this metal if the number of formulas were greatly reduced and the process of manufacture so standardized as to insure a uniform quality of alloy. Except for a few cases, but 2 babbits, one a lead base alloy, the other a tin base alloy, each being the best that can be made, are required for a complete line of bearings, ranging in weight from a few ounces to several tons. The best quality of metal should be used.

Before pouring, the molten babbit should be kept at a temperature of about 870 deg. F. and regulated so as to give a variation of no more than 10 deg. above or below this point.

The temperature should be raised slowly and the babbit thoroughly stirred, this being necessary in order to prevent certain of the constituent metals from rising to the top and becoming oxidized, as well as preventing the heavier metals from sinking to the bottom of the pot, and producing a nonuniform alloy.

Bearing Shells

Except in special cases, bearings are seldom made of solid babbit, the general practice being to use the babbit only as a lining in cast-iron, malleable-iron or bronze shells.

On account of its strength, good working qualities and low cost, cast iron is the most commonly used material for bearing shells, while where greater strength and toughness are required, malleable iron is employed. Cast steel is not a good material, owing to its tendency to warp when the casting strains are relieved and also after babbiting. On account of the reliability, bronze is employed for bearing shells in railway work; for, even though accidental heating results in melting the babbit lining and causing it to run from the shell, the use of bronze makes certain the completion of a run.

All cast and malleable iron bearing shells are provided with cast anchor holes to hold the babbit lining in place and prevent its turning with the revolving journal. Bronze shells properly tinned require, as a usual thing, no other provision for holding the babbit lining in place; but, in some cases, either anchor holes are drilled diagonally or undercut grooves are added to make doubly sure that the babbit lining does not become loose.

Iron bearing shells should be cleaned before babbiting and all sand and scale removed by tumbling, sand blasting or pickling in a hot soda ash solution or in muriatic acid. If necessary, the sand should be loosened from the anchor holes by hand, for it is absolutely essential that no sand or grit remain to work its way into the babbit lining. To assure uniformity in grain, wear and thickness of lining, all bearing shells should be bored before babbiting.

Bronze bearing shells should be tinned by immersion in half-and-half solder before babbiting, great care being taken to secure a perfectly uniform, clear film of tin over the entire surface to which the babbit is to adhere; otherwise, loose linings will result. Tinning on iron cannot be depended upon since, at the temperature of molten solder, iron and solder do not alloy.

Pouring the Babbit

Careful attention should be given to the way the molten babbit is poured into the bearing shell, since this is perhaps the most important operation of all. To secure good results, the babbit should be poured at the correct temperature; if too high, shrinkage will occur, the babbit will become oxidized, softened and dirty and its antifrictional qualities will be lowered. If the babbit is poured at too low a temperature, a lining having a coarse granular formation will result. In addition to this it is advisable to preheat the shells and mandrels to a temperature of from 200 to 300 deg. F.

To obtain the best results when pouring the babbit, a ladle of the self-skimming type should be used, preferably one having a welded or riveted sheet-iron bridge, so as to give the right size of stream for the bearing being poured, thus preventing splashing, as well as keeping dross from being poured in with the babbit.

Babbit, especially the lead alloy, is weak while hot and bearings must not be roughly handled or thrown about while the lining is cooling, as this is liable to break anchors and loosen the lining.

Best results are obtained by pouring the babbit with the bearing shells in a vertical position. If it is impossible to do this, due to the irregular shape of the mandrel, it may be inclined and poured at the most convenient point. When split bearings are poured at an angle, care should be taken to place the shell so that the face is nearest the table. Split bearing shells are sometimes placed horizontally with the convex side up over the mandrel on a surface plate, and the babbit poured through holes left in the casting for the purpose.

Finishing

Metal fins and burs are readily removed with an ordinary draw knife or spoke shave or with a hot soldering iron. Lubrication holes should be cleaned with a hot iron and all bearings thoroughly peened before machining. Oil holes are generally cut in the surface of the finished bearing by hand (except in die cast bearings) because in most cases the babbit lining is too thin to allow casting the grooves.

Repair Work

The easy working qualities of babbit make it especially suitable for repair jobs in the field, a good tin base alloy, on account of its ability to stand more mistreatment than a lead base alloy, being generally better for this work. When no equipment is at hand and the cost of building a mandrel is prohibitive or the time required to build it cannot be spared, successful work can be done with a mandrel of sheet iron. Paper may be used for bore allowances, asbestos cord to provide cast oil grooves, and clay and friction tape to seal up openings. In some cases, it is permissible to pour the babbit into the properly prepared bearing shells with the journal in place, but the housing cover should be heated clamped in position to heat up the housing and axle. All bearings should be poured at once and great care taken, especially with small journals, to prevent springing.

Babbit may be melted in the pouring ladle over an open fire and the temperature assumed as right when a pine stick used for stirring, chars but does not ignite. The mandrel temperature is right when water evaporates rapidly from its surface without sputtering.—The Electric Journal.

Research Fellowships

In the Engineering Experiment Station, University of Illinois, Urbana, Ill.

TO EXTEND and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 Engineering Experiment Station Research Fellowships. One other such fellowship has been established under the patronage of the Illinois Gas Association. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of the Research Fellows is required in connection with the work of the department to which they are consigned, the remainder being available for graduate study.

Nominations to these fellowships, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station each year not later than the first day of February. Nominations are made by the Station Staff, subject to the approval of the Executive Faculty of the Graduate School and the President of the University. Nominations are based upon the character, scholastic attainments, and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following their undergraduate work. Appointments are made in the spring and take effect the first day of the following September. Vacancies may be filled by similar nominations and appointment at other times.

The Engineering Experiment Station, an organization within the College of Engineering, was established in 1903 for the purpose of carrying on investigations in the various branches of engineering, and for the study of problems of importance to engineers and to the manufacturing and industrial interest of the State. Research work may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and in theoretical and applied mechanics.

The work of the Station is closely related to that of the College of Engineering, and the heads of departments in the College constitute the administrative Station Staff. Investigations are carried on by members of the Station Staff and other members of the instructional staff of the College of Engineering, by special investigators employed by the Station, and by the Research Fellows.

Additional information may be obtained by addressing: The Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

In response to an inquiry concerning the attitude of the War Department toward graduate students in engineering, Dr. S. P. Capen of the United States Bureau of Education states that the office of the Chief of Engineers has ruled that resident graduate students in engineering who are candidates for an advanced engineering degree may avail themselves of the privileges provided by the new regulations, under which engineering students may be enlisted in the Enlisted Reserve Corps of the Engineer Department and placed on the inactive list until they have completed their educational training. It is assumed that this ruling will apply to the holders of these Research Fellowships.

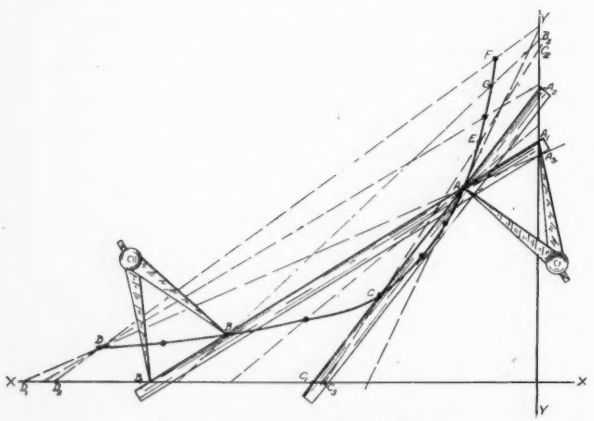
A firm in Mauritius wishes to buy engines and building material suitable for the erection of sugar factories. Further information can be had from the Bureau of Foreign and Domestic Commerce, Washington, D. C., asking in regard No. 26,232. Also, the manager of a sawmill in Siberia wishes to buy steam and gasoline cable and engine equipment for hauling logs. The number of this inquiry is 26,239.

Comments Upon Cards from Nordberg Engine

I NOTICE in the issue of Dec. 15, page 982, some reproductions of indicator cards taken from the low-pressure cylinder of a cross compound engine of my design.

If it had not been stated in the article pertaining to these cards that they were taken from the low-pressure side of a compound engine, I would have assumed them to be the cards from the high-pressure cylinder, as the exhaust line resembles very much one produced by the variable receiver pressure of a cross compound engine. There is no scale attached to the cards.

If these cards were taken from the low-pressure cylinder of a cross compound engine, the rise in the exhaust line towards the middle of the stroke must be due to a pulsation of the pressure of the exhaust steam and would call for a receiver in the exhaust pipe close to the low-pressure cylinder. A pulsation such as indicated by



LAYING OUT MARIOTTE LINE

this exhaust line is often found in the steam pipe of a power plant. An exhaust line such as shown on these indicator cards could not be produced by an improper setting of the exhaust valves. The run of the exhaust line is largely determined by the amount of exhaust lead and the time in which the exhaust valve can be opened wide by the valve gear. My experience is that if by insufficient lead or sluggish valve motion the exhaust line commences to rise early in the exhaust stroke, it will never fall during the stroke, but rise continually up to point of compression; in fact, will produce a much earlier compression than determined by the valve motion. This fact shows the necessity of designing the exhaust valve gear so that the exhaust valve opens very rapidly and it should be set with very ample lead. Apparently this was well known to George H. Corliss, who used great care in proportioning the valve gear operating the exhaust valves of his engines, and the practice used by some engine builders of abandoning the wristplate motion for exhaust valves is wrong.

It is possible to predeterminate the run of the exhaust line if the element of the valve gear and the valve setting are known, particularly if the quality of the steam during exhaust is known with a fair degree of accuracy. In cases where the exhaust line of the indicator card show an irregularity, like in the cards referred to above, a simultaneous indicator card should always be taken from the exhaust chest. If such a card should be taken in the present case, it is safe to say that it would show the same variation in pressure as appeared in the indicator card from the cylinder, showing that this irregularity in the exhaust line is caused by a pulsation in the exhaust steam.

As intimated above, there is very frequently a pulsation in the steam pressure in the steam pipes leading to an engine and sometimes, also, in the steam pipes leading to the low-pressure cylinder of a compound engine, if the pipe from the receiver to a low-pressure cylinder is long or contains several bends, so that judgment cannot be passed upon the valve action of a steam engine by the shape of the admission line unless the variations in the steam chest pressure are also known at the same time. Therefore it is in every case of great importance that an indicator card be taken from the steam chest at the same time as from the cylinder. Without this precaution, the indicator card is of little value as far as the admission line is concerned and often a fault which really is in the steam pipe or its connections is charged to the valve action.

The admission losses in most engines are not very great in the valve ports, but often quite excessive in the steam pipe proper. In the absence of indicator cards giving the variation of pressures in the chest, the cards from the cylinder are of value only as far as the expansion and compression lines are concerned.

I thought in this connection that the following method of laying out the Mariotte line might be of interest to readers:

The usual method of laying out this line is by means of ordinates. That method requires the mounting of an indicator card on a drafting board and subdividing it into a number of equal parts. Then, after the line of perfect vacuum and clearance has been drawn on the card and the ordinates at the different subdivisions drawn, the points of the Mariotte line are determined by means of triangles. After all this is done, the card is all covered with pencil marks and the method is rather cumbersome unless the work is done in a drafting room.

By the following method, this work can be done easily and quickly right in the engine room with no other tools but a straightedge and a pair of dividers. The only lines that need to be drawn on the indicator card are the lines of absolute vacuum and a clearance line.

I herewith enclose a sketch explaining this method:

X—X is the line of absolute vacuum and Y—Y the clearance line on the indicator card. Assuming now that we desire to draw a Mariotte line passing through point A on the card:

Take a straightedge (a wooden one is preferable to a steel scale), place the straightedge in any position so that it touches the point A and take with a divider the distance A—A_1, A_1 being the point where the straightedge intersects the clearance line Y. Now set off the distance B—B_1, equal to A—A_1, *but draw no line,* B_1 being the point of intersection between the straightedge and the line of absolute vacuum. B then is a point on the Mariotte line. Swing the straightedge around point A so it touches the clearance line in point A_2. Set off the distance A—A_2 along the straightedge from the point of its intersection with the vacuum line C_1 so that C_1—C is equal to A—A_2. C is then another point on the Mariotte line. The straightedge can now be swung around point A to the limit of the length and width of the indicator card and other points on the Mariotte line determined in the same manner. For instance, the last point that the length of the indicator card will allow to be determined would be the point D, the point D_1 being the extreme left end of the vacuum line on the paper, A—A_3 being equal to D—D_1.

In order to determine points on the Mariotte line located above the point A, select any of the other points on the Mariotte line previously determined, as for instance point C, and place the straightedge through C. Turn it so it passes through the uppermost point on the clearance line at point C_2; it then intersects the exhaust line in point C_3. Now take the distance C—C_3 in the divider and lay off the distance C_2—E. E is then a point on the Mariotte line located above A. By placing the straightedge so it passes through the point, Y, and the already determined point D on the Mariotte line, and setting off the distance Y—F, equal to D—D_2, we obtain the highest point F on the Mariotte line that can be determined within the limits of the card.

It is plain that you can now take any of the determined points as a starting point and plot the curve point for point, without in any way marking up the original indicator card, except by drawing the lines of absolute vacuum and the clearance line.

This method is more accurate than the method of using ordinates. The principle underlying this method is very well known as a mathematical proposition, but the above described mode of using it is not.

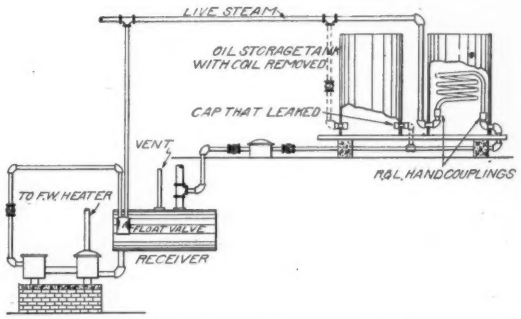
As stated, by this method indicator cards can be laid out in the engine room in a very few minutes and all that is needed is a flat board to lay the cards on, a straightedge, and a pair of dividers. A square is needed only for drawing the vacuum and the clearance line. I have been using this method of laying out Mariotte lines for a number of years and have done the work of laying out as soon as the indicator cards were taken and in less than 5 min. time enough points can be plotted in an indicator card to enable one to form some judgment regarding the economy of the engine.

BRUNO V. NORDBERG.

Oil in Steam Boilers

READING H. A. Jahnke's letter in the Nov. 15 issue of Power Plant Engineering reminded me of a similar case of oil getting into steam boilers.

The coils in one of two olive oil storage tanks shown in the accompanying illustration were removed and caps attached to the nipples on the inside of the tank. Within a few days, however, I noticed oil in the boilers and upon investigation I found the cause of the trouble to be due to a leak at these caps, allowing the oil to go to the receiver, from which it was in turn pumped through the closed feed-water heater to the boilers.



ARRANGEMENT OF EQUIPMENT SHOWING HOW OIL REACHED BOILERS

The trouble was, however, entirely eliminated by disconnecting the tank from the return line and capping the nipple outside of the tank.

JAMES G. SHERIDAN.

Why Some Plants Prove Failures

WE OFTEN HEAR the question raised as to why the central stations obtain control of so many isolated plants. And while it may be profitable for some of these plants to shut down and purchase outside current, this is, however, not true in the majority of cases and the only answer which may be given to the above question is false economy and carelessness on the part of the operating engineer.

Fifteen years ago a plant consisting of a 72-in. horizontal return tubular boiler and one 100-hp. four-valve engine, was installed in a five-story building. For 10 yr. this equipment was fairly well loaded and the plant proved a good investment, the tenants paying a good price for the heat and electric current.

Gradually, however, the tenants moved out, one by one, the building became partially vacated, and as a result the power plant was carrying a load of no more than 30 hp. of which 10 to 15 hp. was friction load. In this case, it paid to discard the plant and take current from the central station.

In a large hotel were installed two 60-in. horizontal tubular boilers, two high-speed engines, a five-ton ice machine, two elevator pumps and two plunger type of elevators. This plant had been running for 8 yr. when

both boilers became badly bagged and the pressure as a consequence was reduced first from 100 to 60 lb., and then to 50 lb. Within the following 4 yr., or 12 yr. after its erection, the boilers were good only for heating and the engines and pumps for the junk pile.

The downfall of this installation was due entirely to ignorance and carelessness on the part of the engineer. He might have had anything and everything required for the proper maintenance of his plant, but he preferred to practice the wrong and detrimental form of economy and as a result became an ally to the central station interests and an enemy to the isolated plant.

Upon a recent visit to a large plant, I came across conditions which happily are not seen very often. Entering the boiler room, I noticed that the equipment here installed consisted of six large stoker-equipped water-tube boilers, four of which were in operation. The steam pressure was down to 65 lb., and the fireman was on a steady go from boiler to boiler slicing and leveling the fires.

Approaching the fireman, I inquired how things were going and in reply he said, "Rotten, the trouble is that they are trying to evaporate 9 lb. of water for every pound of coal." I guess he thought that the more water they were evaporating the more difficult it would be to maintain the steam pressure.

Being more or less inquisitive, I followed him about and glancing in at his fires, I noticed the grates on both sides bare for a distance of 18 in. from the doors. On my inquiring why he kept his fires in that condition, he blamed the chutes, forgetting that he could level off the coal in the magazines and his fires in the furnaces.

In the engine room things were, however, different, all metal work highly polished, and not a bit of dirt to be seen anywhere. A thing which did attract my attention was the great number of meters which had been provided, and no cheap ones at that. This was well and proper, but in my opinion what this plant needed more than anything else was CO_2 recorders and steam flow meters.

I inquired of the engineer why the steam pressure was low; he informed me that while they tried to carry 125 lb. whenever possible, it was very seldom they could do so. Of every hour he had to spend 35 min. reading his meters, then had to look over his pump and ice machines, and as a consequence had little or no time to look after the boiler room end of the plant.

This is considered one of the nicest isolated plants in the city where it is located.

In a plant installed some years ago, quite a number of pumps were required and upon recommendation of a consulting engineer, but contrary to the advice of the operating engineer, only steam driven machines were purchased. Within a short while, however, due to operating conditions peculiar to this plant, the running expenses rose to an enormous figure; in fact, they became so high that the owner was forced to dispose of the steam pumps and install the belt driven power pump recommended by the operating engineer.

In case of such a failure, who can be blamed? The owner cannot be expected to look at such problems in the same light as does the engineer and undoubtedly the consulting engineer acted to the best of his ability. Perhaps his ability is to blame. C. M.

A Troublesome Valve

In a barge mill where I was employed, there was a steam engine of about 25 hp., used exclusively for generating electric current. One afternoon, steam was turned on to start, but the engine did not make over one and one-half revolutions; by opening the valve wide, about another half revolution was all which could be obtained. In a short time all the engineering crew was on that floor. The engine could be turned by hand easy enough, the eccentric was in its place, the piston was not off the rod, the steam chest was getting steam, but still we could not get over two revolutions.

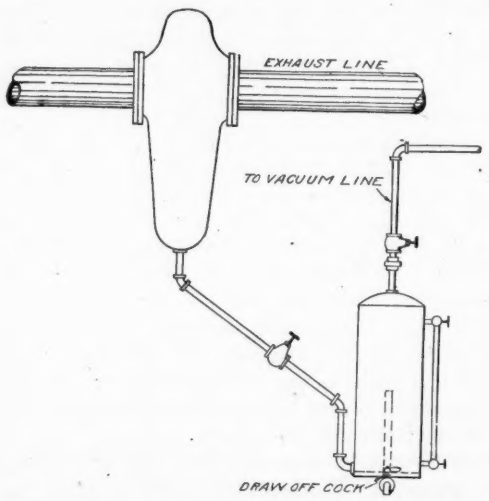
By taking the valve apart (a common globe valve), we found the seat loose in the casing, so that the least steam going through blew it up against the disk. In taking out the seat we saw several large center punch marks which had become worn smooth, so that the original "tight fit" was gone. We tinned the outside of the brass seat and while hot pressed it in place with the hand wheel. The next day a new valve was ordered.

Chas. Labbe.

Homemade Vacuum Line Oil Separator

As every engineer experiences more or less trouble with oil and grease getting into his heating system and from there into his boilers, etc., this idea may prove of benefit to someone.

Having had considerable trouble with stoppage of vacuum traps with oil and grease, we decided to investigate why our separator did not separate. The result was that we decided our trouble was caused by a lack of pressure and sometimes a considerable vacuum on our exhaust lines. The vacuum returns on radiators and risers producing considerable vacuum on the exhaust



OIL SEPARATOR WITH VACUUM TANK RECEIVER

system, at times sufficient to pull the oil and water through the separator and into the heating system instead of allowing it to run into the trap provided to drain the separator, we therefore decided to try the experiment herewith illustrated.

We installed a galvanized tank 14 in. in diameter by 36 in. high, with a 30-in. water glass on one side and provided with two openings at the bottom on the side, one opening in the center of the bottom and two open-

ings in the top. A pipe was screwed up through the opening in the center of the bottom 18 in. long or to the center of the tank, from the bottom of this pipe we brought a connection out to lower edge of the tank and screwed on a bib cock. The drain from the separator was then connected to a side opening near the bottom of the tank, as shown. From the top of tank a ½-in. pipe was run to vacuum return system near the vacuum pump. The tank was then filled half full of water, and the separator drain valve was opened wide, and the vacuum valve was opened slightly—it does not require to be opened wide. We have been running this device for some time and it removes every bit of the oil which we filter and use again. It is necessary to drain the tank into the oil filter every time the gage glass fills nearly to the top, two or three times daily.

R. L. WELLS.

Oil in Gas Engine Cylinder

WITH REFERENCE to the troubles of C. E. M. as related on page 871 of the Nov. 1 issue, I wish to state that I have experienced similar trouble which I eliminated by the use of two narrow rings in each groove instead of a single wide one. These gave entire satisfaction and are not nearly so great a source of trouble as some of the leak-proof rings found on the market today.

When installing, the rings should be so placed as to bring the slits on opposite sides of the piston.

J. R. DUNN.

To Earn More, Advertise More

I HAVE heard asked, of what value is advertising to an engineer?

For illustration, several years ago I entered the employ of one of the largest companies in the United States, having 26 large pumping plants in one state. I entered their employ as watch engineer, one of 52 engineers. After I had been in their employ 4 mo. and had met the general superintendent once when he was upon a tour of inspection, an article on boiler explosions, of which I was the author, appeared in a technical magazine devoted to their business.

Within a week after this appeared, the company boiler inspector resigned and I received a wire to report to the general office to relieve him.

Now, I was a stranger to the company; in fact, I had not been in the state a year, had brought no letters of recommendation when I entered their employ; but I received the promotion over 51 other men, some with 10 yr. service.

The general superintendent, as his secretary afterwards informed me, was reading the article I had written when the boiler inspector's resignation arrived by mail. I received the promotion from the written article.

All up-to-the-minute managers and superintendents keep in touch with technical subjects written from the men on the job, and any employe having an article in a magazine is brought to their notice much more forcibly than if the master mechanic had said, "John Smith is a very good engineer."

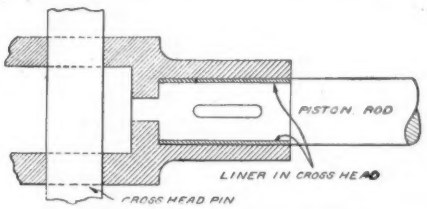
There is no more dignified and far-reaching method for an engineer to advertise his personal worth than by contributing to a technical magazine carefully prepared articles upon subjects of which he is master.

C. E. ALDRICH.

Loose Piston Rod Causes Knock

ONE SUNDAY our engine, a 20 and 38 by 54-in. tandem compound condensing unit, was opened for periodical inspection; but as all was found in good order, no changes were made, nor was anything repaired or renewed. While starting on Monday morning, a distinct knock was heard every time the crank passed the dead center, on the side away from the cylinder. As the load increased the knock became more intense, until it dislodged the crank shaft bearing. Every possible cause was thought of, but in vain. The peculiarity of the trouble was that you could not locate the knock. If near the crank, you found it there; while if you stood near the crosshead, it would appear to come from this point.

As the main bearing was shaking a great deal, the engine was stopped, the holding down bolts tightened and a 1/16-in. liner was placed between the connecting rod and crosshead brass, thinking that perhaps the piston might be coming a little further from its position and so, jumping up the ridge, it might be causing the knock. While doing so, it was found that the thin liner of the key joining the crosshead and piston rod had moved away on one side; it was made good before starting the engine again. Then there was no knock at all; it worked well for the rest of that day, and up to Tuesday noon. Then, however, a light knock was again heard, which by Wednesday morning became quite heavy; in fact, so much so as to cause the crosshead pin brass to heat, although this had been slackened the previous night.



LOCATION OF LINER IN CROSSHEAD

The engine was stopped to cool the brass, and without any thought the crosshead key was tried with a sledge hammer, to see whether it was tight or not. With every stroke of the hammer the key moved inward about ⅛ in., and with a few more strokes went through entirely, necessitating the removal of the key. A ⅛-in. liner was then placed at the back of the key to make it wider and the key driven in tight; the crosshead pin brasses were also made to fit tight. On starting the engine, it was found that the knock had totally disappeared.

Now, the cause of the piston rod getting slack was, in my opinion, as follows: There was a 3/16-in. liner in the crosshead boss fitting with the taper of the rod, as shown in accompanying illustration. The liner was driven in after it was finished on the lathe, and the 3/16-in. metal being too thin, must have become out of shape. When the crosshead and piston rod were disconnected and dimensions of the piston rod taper and crosshead bore were checked, a difference of about 1/32 in. was found toward the thin end of the taper.

At present, the engine runs without any knock; but I have decided to change the liner in the crosshead, and this time I shall finish the taper bore, after driving the liner in the crosshead and taking the whole crosshead on the lathe.

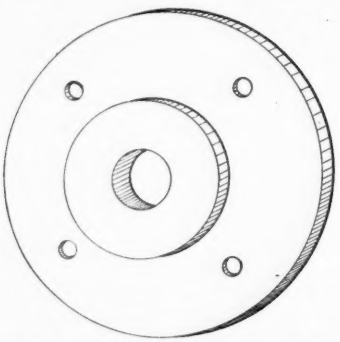
N. N. BAVA-ADAM.

Knocking Exhaust Valves

SHORTLY AFTER our 350-hp. cross-compound Corliss engine was installed, the exhaust valves on the high-pressure side developed a decided knock, which was very annoying to me.

As this was my first experience with a Corliss engine, it took some time to find a remedy that was satisfactory. I talked with several of my friends who were running this type of engine, but didn't seem to get much of an idea how to stop the knocking unless I put in some shims, which I didn't want to do if I could help it.

So I thought I would try another scheme. I went back after supper one evening and took off the back bonnet of one of the valves and looked the job over. Pushing the valve ahead as far as it would go, I measured the space left to find out how much end play I had, and here was where I got a great surprise. Judging from the knock, I thought I would find at least ⅜-in. play, but there was only 1/32 in. I took the diameter of the inside of the valve chamber, then I laid out a circle on the face of the valve bonnet 1/64 in. smaller, very carefully, so that when the bonnet was bolted on, the centers would exactly face each other. Then I put the bonnet in a chuck and turned 1/32 off the face in, as far as the



BACK BONNET ON EXHAUST VALVE WITH PROJECTION TO PREVENT END PLAY

edge of the circle. This left a projection 1/32 in. high, as shown in the sketch, and when the bonnet was put in place this projection entered the valve case and took up all end play without the use of shims or any loose pieces to get lost if for any reason the bonnet had to be removed. It didn't take any longer to turn off the face of the bonnet than it would to fit a shim.

When we started up the next morning the valve worked noiselessly and without a hitch; the next evening we fixed the other valve and then forgot them.

Care must be exercised in making this repair not to turn too much off the bonnet, as this will jam the valve when you start up and make trouble for you.

A. A. A.

Answering an Ad

THE LETTER under this caption in the Dec. 1 issue has appealed to me in more ways than one.

First, I wish to agree with Mr. Daly that every engineer should be able to write an intelligent letter, although personally I never pick a man by his letter.

"Why?" you may ask. Well, here's the answer:

Several years ago it became necessary to hire a watchman, so an ad was inserted in a local paper. The ink could hardly have been dry on the paper when applications began to arrive. The watchman's duties were many and the wages (not salary) were $14 per week of 84 hr.

We wanted a man capable of cleaning the fireboxes of two 6-ft. high pressure boilers, getting in coal for his shift (3 tons), getting out the ashes and winding 24 boxes every hour.

There were applicants with red noses that savored of too much rye; there were fine looking applicants with no muscle, and there was just one who could read and write the English language and fire boilers.

I picked this man as the winner, but the manager wished to try a correspondence watchman.

The application would have suited Mr. Daly I feel sure. It told the experience of applicant for 10 yr., his height, weight and horsepower, and I had never in my experience seen writing to equal that application. It was as if engraved.

"If you can get a watchman with all the qualifications specified herein for 14 iron men per 84 hr., do so, by all means," I remarked to the manager, "and for a few extra he might do your bookkeeping on the side, for I swear there's nobody in this office that can handle a pen like this man."

In due time, our watchman arrived. He came from a city a few miles to the north of us and so the delay was acceptable. The manager called me to the office to see the new addition to our family. He introduced us as follows: "Chief, meet Mr. Slitzenburgher. Mr. Slitzenburgher, our chief, Mr. Thumb."

"Vell, vell, I dink I vork for you, yes, if I like you, vat?" says S.

"Are you the man that wrote for this job?" I asked him.

"Mr. Cheese," said S., "dot iss one bretty goot yoke—my daughter wroted the letter."

What's the use of telling more of this applicant. He only lasted ten nights and only wound fifteen boxes on the best dial he made.

I wanted an engineer once upon a time, and I worded the ad as follows:

Wanted: An engineer to sleep days and work nights. I can't stand the smell of liquor and the insurance company won't stand for smoking. Apply to Mr. Thumb, Cook and Company.

I got more answers in person and by mail to that ad than I ever did from an ad before or after.

One middle-aged applicant in particular suited my taste to a T, but imagine my surprise when he said: "I don't want a job, but just called to get a look at the man that wrote that ad.

Another applicant wrote a nicely worded application and ended by saying: "I don't smoke, chew or drink, and I can run any damned engine this side of Hades, night or day, stationary, locomotive or marine."

As this engine to be operated was not at that time damned, this applicant did not fit.

I can't quite agree with Mr. Daly in calling the indicator a dazzler and hypnotizer, but I will admit that the man who buys the coal scoop should also buy the indicator and the CO_2 machine.

Where I am employed one company pays for its power upon the report that the hypnotizer shows and

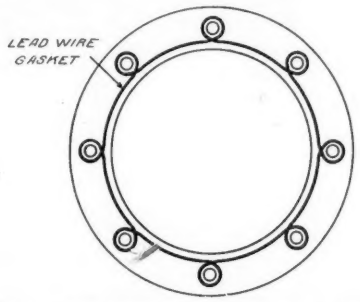
same pair of instruments earned several hundred dollars for the owner when a water turbine was installed that fell short of guaranteed power developed.

I believe a pretty good way to learn to write an intelligent letter is to write to your engineering magazine about your experiences from time to time, and if the said magazine editor is good enough at heart or short of copy, or perhaps both, your letter will appear some fine day and you will wonder if you really did write such a poor essay.

The next attempt will be better, and after awhile you will perhaps dare sign your proper name. Up to the present going to press the undersigned has been contented just to sign TOM THUMB.

A Temporary Gasket

THE GASKET of one of our low-pressure pump heads was torn to pieces in removing the head to examine the plunger. When we were ready to replace the head it was found that there was no packing on hand except some high-pressure sheet material. This the chief said

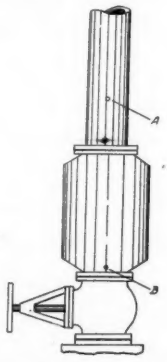


USING LEAD WIRE FOR CYLINDER HEAD PACKING

we could not use, as it would be wasting expensive packing. He then proceeded to show us how to make a temporary low-pressure gasket of lead wire, as illustrated in the accompanying sketch. C. H. WILLEY.

An Odd Cause of Trouble

A NUMBER OF YEARS AGO the writer was called into a plant to investigate the cause of trouble encountered in the lubrication of a high-speed engine which had just been overhauled and moved to a new location. All parts



FORMER AND PRESENT POINTS OF DISCHARGE FOR THE LUBRICATOR

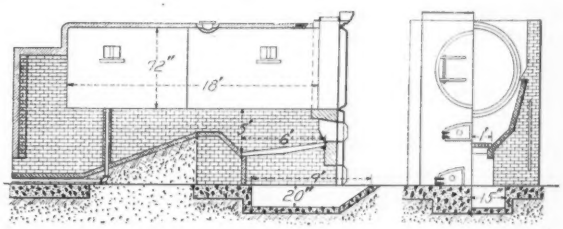
of the engine were carefully examined and found O. K. It was also found that the engine was equipped with a steam drier on the throttle so that the trouble could hardly be caused by water in the steam. The writer was reaching up to get a sample of oil from the automatic lubricator when the cause of the difficulty dawned upon him. The lubricator connection was made in the steam pipe ahead of the separator, at A in the sketch, and naturally the separator was removing a large percentage of the oil being delivered by the lubricator. The connection was broken and the lubricator was arranged to discharge through the neck of the lower part of the separator at B, whence it went direct to the valves and cylinder. When the steamfitter was questioned, he stated that the lubricator was placed where it was because the directions called for locating it "in the pipe" ahead of the engine.

This incidentally also solved the trouble they were encountering with oil in the boilers, because the separator drip containing this oil was being discharged directly into the make-up tank through a steam trap.

M. A. SALLER.

A Satisfactory Boiler Setting for Wood Fuel

REALIZING that our 150-hp. boiler was capable of doing better work, we re-arranged the setting, as shown in the accompanying illustration, the scheme employed being copied from a print loaned us by a boiler insurance company. The present arrangement gives us nearly



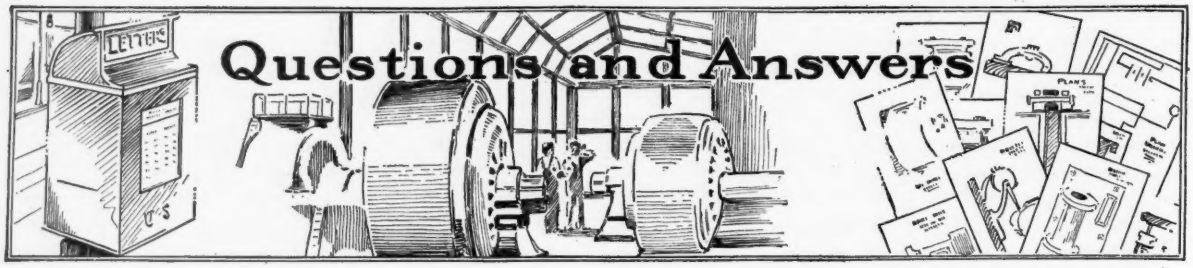
FORM OF BOILER SETTING WHICH PROVED ENTIRELY SATISFACTORY FOR THE BURNING OF WOOD

⅓ greater efficiency with a saving of nearly that much wood. Both cord and green mill may be burned equally well. F. P. ROWLEY.

Correction Note

IN THE ARTICLE on Valve Setting, published on pages 936 and 937 of the Dec. 1 issue, by Mr. Waldron, the author has called our attention to some errors that will cause confusion if directions are followed as outlined. In illustration Fig. 4, the letter O should be located at 90 deg. from and above line A E, and the statement within the parenthesis, second line below Fig. 4, should read, "Starting with the exhaust wristplate in central position, exhaust valves line and line, and exhaust eccentric in quarter position at O, under the assumed condition."

KEEP THOSE heating surfaces clean. It takes only 1/32 in. of soot to cause a 10 per cent loss, and the scale inside is about as bad. Scrape the tubes, inside and out. Treat the water to prevent hard scale, and blow out deposits of sludge frequently. Coal is needed to win the war, and every bit wasted by dirty boiler surfaces is a help to our enemies.



Why the Noisy Compressor

I HAVE a Vilter ammonia compressor, vertical, single-cylinder, 5 by 6 in. single action. In the cylinder there is a loud, annoying noise.

To make it plain, the driving wheel is 36 in., run by a motor which has a 6-in. pulley. At 900 speed, the knock which I speak of has a metallic sound. I always carry the crank case half full of oil; the connecting rod bearings are O.K. The machine was a used one when purchased. I never saw it run before we purchased it, but I installed it and it seems to work all right in every other way. Please give me complete data on this matter.

After this plant has been idle for several months are there any special precautions to take when starting up again? H. R.

A. As it is impossible to say just what causes the knock in the ammonia cylinder, the following defects will be found to be the causes of most knocks:

The ammonia piston striking the compressor head. Measure the clearance space between the piston and head by means of a piece of fuse wire or strip of lead. To do this, take out one of the valves and insert the wire. (Have the wire long enough so as to retain a firm hold on one end.) Turn the machine over one complete revolution by hand. The wire will be flattened to the thickness of the space between the piston and the head.

The clearance space in a machine of that size and speed should be about 1/32 in. when the rod is at its usual running temperature. If the clearance is not sufficient, screw the rod into the crosshead to increase.

Some of the small upright ammonia compressors are constructed without a piston rod after the same plan as a gas engine. In this type, the connecting rod extends from the crank shaft to the crosshead pin, which is fitted in the piston.

To increase the clearance in this type, a heavier gasket must be used between the top of the cylinder and the head. Here it is well to remember that rubber will not squeeze thin unless it can spread out, so do not put a 1/16-in. gasket in the groove and expect it to press down to 1/32 in. when pulled tight.

On this type compressor, however, something must be mechanically wrong to allow the piston to strike the head. The clearance was adjusted when the machine was made and assembled. The wear of the bearings will increase instead of lessen the clearance, so if striking does occur, the reason must be found.

If the main bearings have been re-babbited, or new brasses put on the crank or crosshead pin, the reason of lessened clearance could have been caused by the babbit being too thin in the main bearings, or the new brasses may be a little different to the original ones.

In this type compressor, great care must be exercised when re-babbiting or replacing parts, to see that the clearance is not affected.

Some pistons are made with a follower plate, secured to the spider by means of flush cap screws. One of these screws becoming loose will allow it to strike the head. Some pistons are secured to the rod, with a flush nut. The loosening of this nut will cause it to strike the head, and will also allow the piston to work back and forth on the rod. A piston moving as little as 1/64 in. on the rod will cause knocking. The nut may be perfectly tight on the rod, and still not make up tight enough to hold the piston to the shoulder. In such a case, the nut must be taken off and a thin washer put on. Then the nut is set up tight and if it extends beyond the face of the piston it must be chipped and filed.

Striking the head can also be caused by the valves which are inserted in the head. Grinding in of the valves and valve cages to insure their tightness often allows the cage or valve to project through so as to extend below the under face of the head. If such trouble is found, the projecting part must be faced off flush with the head. And if such facing weakens the valve, or cage, new ones must be put in.

Another reason for knocking is a valve cage being loose from its seat in the head. When putting in the cages, measurements must be taken, so as to be sure that the bonnet presses the cage down hard.

Defective or broken valves or springs or sticking valves also cause knocking.

Broken or poor fitting piston rings is another reason for noise.

If the piston is a loose fit in the cylinder it will cause a knock by striking against the cylinder wall on the up stroke. On the down stroke the piston will go to the other side of the cylinder, but not with enough force to cause noticeable noise.

The cases stated so far deal with causes of noise in the cylinder itself. It often happens that the knock seems to be in the cylinder, when it really is outside. Loose bearings, loose crank or crosshead brasses, crosshead pin loose in the crosshead, or in the piston, and piston rod loose in the crosshead, are causes of knocking which can easily be mistaken for noise inside the cylinder.

Side play in the crank or crosshead brasses will allow the connecting rod to move sideways and cause a distinct knock.

Frosting back on the compressor too much and allowing liquid ammonia to enter the cylinder will cause pounding.

Another cause of knocking is sometimes found in the packing of the piston rod. At the top end of the

stuffing box is a metal ring (either iron or babbit). This ring or the oil lantern will at times move up and down and cause a noise. This only happens when the packing above the oil lantern is worn or not properly put in.

The amount of oil carried in the crank case can also be the cause of a knock seemingly in the cylinder. The crank should dip into the oil only enough to supply the required amount for lubrication. If the oil is carried high, the crank hits the deep body of oil with a solid sounding slap such as may be made by taking a flat stick and striking hard and flat into a tub of water.

After a small plant has stood idle for several months the machine should be watched carefully when starting up. There is always a danger of dead liquid, oil or moisture being pocketed in some part of the system. This may come to the machine in a slug and do considerable damage. Some reliable man should stay close to the machine so that it can be shut down at the first warning.

Of course, before starting the machine at all, every valve on the entire system should be examined so as to know for certain that the proper valves are open. The valves on the discharge side from the compressor to the ammonia condenser must be wide open.

If a plant is shut down for several months, it should receive a thorough overhauling. The machine should be taken apart and all defects repaired and adjustments made, so that service will not be interrupted during the time that refrigeration is needed.

The coils of the evaporating and condensing sides should be cleaned with steam and air on the inside and brushed and painted on the outside.

The low-pressure side of the system should be tested with 100 lb. air pressure and the high-pressure side with 300 lb. A. G. Solomon.

Economical Use of Coal

Will you kindly tell me the best methods and rules for firing to save coal? What is the cause of the shortage of fuel? It is predicted that there is going to be a coal famine. J. H.

A. The best method of firing coal depends somewhat on the coal you are using and the furnace that you have. In the past, the coal in your region has been usually the steam sizes of anthracite, but I presume that this year you are using bituminous.

To handle bituminous coal successfully requires a larger fire box and a larger combustion chamber than is necessary for the anthracite. This may be difficult to get without altering your boiler setting; but if you are forced to use bituminous coal continuously, it is probable that the change of setting will pay in the end. If you can tell us the size and type of your boiler, we can give you some idea of what the dimensions of your setting should be.

As to the handling of the furnace, you may use either the coking method or the alternate firing method. When using the coking method, the coal is fired near the front, practically on the dead plate just in front of the firing door, and allowed to lie there while the volatile matter is distilled off somewhat gradually—the gases passing over the top of the hot fire at the back of the fire box, and thus being burned completely to CO_2 before reaching the combustion chamber.

When the fresh coal is well coked and the volatile matter has been distilled off, which can be told by the appearance of the fuel and the disappearance of smoke rising from the fuel pile, this coal is pushed to the back of the grate and new coal fired at the front. The ordinary periodical breaking up of the fire by the use of the slice bar, and cleaning out of clinker is, of course, necessary.

The alternate firing method is available where there are two or more firing doors. In this method, first one side is fired, then the other. Fresh coal is spread, say, on the right-hand side of the furnace, covering probably two-thirds of the front end of that side of the grate. When this is coked down, it is spread toward the back of the grate, and coal is fired on the left-hand side—the operation being then repeated.

In either case, the object is to have, at all times in the furnace, from one-third to one-half the grate area covered with live, hot coal, through which a certain excess of hot air will be passing so that this excess air may mix with the gases coming from the fresh coal, and thus furnish sufficient oxygen to burn all the fuel to CO_2. Generally it is necessary to introduce, immediately after firing, some extra air through the openings in the firing door, and this can be closed after a minute or so.

As to the reason for the scarcity of coal, there are three things at work. First, there have been a great many strikes in the mining regions all through the summer, and up to the middle of September. This has cut down the summer production of anthracite coal, which is usually depended upon to accumulate a large reserve stock at the mines.

In the bituminous region, coal is mined only as there are cars to ship it. If there are no cars at any mine today to take away the coal, work is stopped and the miners do not work. The railroads have been congested with freight traffic caused by the large amount of war material that has had to be shipped to Atlantic ports, and the material which has been hauled for the building of cantonments, and to supply the factories making war material. This has resulted in considerable car shortage at the mines, so that altogether a good many mines have been operating, most of the time, at from 20 to 50 per cent under their possible capacity for production.

Spite of this fact, it is estimated that the production for 1917 was something like 50,000,000 tons greater than for 1916; but the great increase in demands for coal, because of the industries requiring fuel to make government material, increased our demand for 1917 by 100,000,000 tons over that for 1916. Even with the increased production, this leaves us 50,000,000 tons short on the demand.

In addition, coal that we are getting is very much dirtier and has a larger percentage of ash than in previous years. This means that a ton of coal has some 100 lb. more ash in it this year than heretofore, and the worst of it is, that it not only wastes that much in weight, but it cuts down the efficiency of burning of all the rest of the coal.

I think the predictions are right—that we are likely to have a serious coal shortage before the end of the winter. I am sure the Fuel Administration will do

all it can to equalize the distribution of coal so that no undue burden shall be put on any industry of any section of the country; but it is likely that all may have to live on short rations, and it behooves us all to see that every pound of coal we burn gives the maximum possible return in heat utilized.—A. L. R., Dec. 29, 1917.

Pipe Dimension Measurements

How are pipes, especially those ranging in sizes referred to as from ⅛ to 15 in., measured? Is it the internal or external diameter which is taken?

G. D.

A. You will find, in measuring piping, that up to 12 in. in diameter the sizes are designated by the nominal inside diameter, while above 12 in. they are specified by their actual outside diameter. No established grading exists for these larger pipes.

For ordinary service, they are made ⅜ in. thick; for heavy service, 14 and 15-in. sizes are 9/16 in. thick; 16, 18, 20 and 22-in. sizes are ⅝ in. thick, and 24-in. pipe is 11/16 in. thick.

From this, the pipe known as ⅛ in. pipe would be ⅛ in. in diameter, internally, with a thickness of perhaps ⅜ in. or somewhat less. The same holds true for the ½, ¾ and 1-in. sizes. In each case up to 12 in., as we have just stated, the diameters mentioned are always the internal diameters, beyond 12 in. the diameters specified are the actual outside diameters.

Reviving Dry Cells

On page 983 of the Dec. 15 issue, A. B. J. asks for a method of reviving run-down dry batteries. To this O. H. H. suggests that he punch holes in the zinc casing and set the cell in a can of water.

Another way is to knock out the sealing material on top of the battery and pour in as much water as possible. Dry cells may also be revived slightly by connecting to a source of direct current in the same manner as a storage battery is recharged; that is, connect the battery in series with a circuit carrying from 6 to 10 amp. A 110-v. lighting system supplying 12 or 14 lights will do. If connected to the positive wire, connect the generator side of the line to the center or positive terminal and the line side to the zinc or negative terminal.

The life of dry batteries may be greatly prolonged by placing them in a tight box and filling the box completely with molten paraffin covering the batteries entirely. Of course, care should be taken to have them properly connected before pouring the paraffin. After cooling, the batteries will be incased in a solid block of paraffin which will prevent moisture and air from coming in contact with them.

A. C. McHugh.

Why the Cracked Blowoff Elbow

Following are some of the replies received from various readers regarding the blowoff pipe trouble as experienced by H. B. and as related on page 945 of the Dec. 1 issue.

The cracked blowoff elbow is undoubtedly due to faulty pipe construction. A 2½-in. extra heavy pipe should be used in the connection between the common blowoff main and the boiler. Forty-five deg. ells should be used instead of 90 deg. ells; or, better still, bend the pipe in a long radius bend. Blowoff connections should be short and direct with as few obstructions in the way of short angle bends as possible. As blowoff piping, being used only at intervals, is subject to sudden and violent temperature changes, provision must be made to prevent undue stresses being set up by the lengthening and shortening of the line due to expansion.

The piping shown is faulty in many respects. Four-in. pipe should never be used in a blowoff connection for return tubular boilers, as 2½-in. pipe is of ample size for any boiler 60 in. or over in diameter. Another bad feature is the reduction in size of the piping, scale which may easily pass the first part of the connection would clog the latter part; and last, but not least, the many right-angle fittings are not to be recommended, as the cracked ell is no doubt due to excessive expansion.

A. C. McHugh.

H. B. states that there is a V-shaped brick wall in front of the blowoff. This causes all the trouble.

This is O. K. under working conditions; but upon shutting down for cleaning the boiler is filled 3 gages, and fire cut out; circulation stops through the blowoff. The V wall is a white heat, front of pipe is kept hot, back of pipe is cooled by air leaking through the setting.

One shut-down would not cause this, but continual expansion and contraction eventually cause the break.

In ordinary working conditions, the 1½ or 2-in. pipe must give way first.

If H. B. will enclose the 4-in. pipe inside the setting with fire brick, leaving plenty of clearance—1 in.—his troubles will be over; and if he will examine the elbow as often as the brick requires repairing, he will be perfectly safe.

There should be at least 1 in. clearance between the wall and shell.

C. E. Aldrich.

The installation of the blowoff pipe and connections are usually done when the boiler and setting are cold. When the boiler is fired up, the temperature of the boiler shell is increased something like 300 deg. F. with the result that a 16-ft. boiler will increase in length by an appreciable amount. In most cases the bottom of a tubular boiler will be lower under steam than when cold, but the amount of lowering in most cases will be slight. It should be kept in mind and allowed for, although the most important change in the boiler is the increased length.

If the front of the boiler is more securely fastened than the back end, then the blowoff pipe will be pushed back when the boiler is fired up. If the outer end of the blowoff pipe is rigidly connected to some object, whether a brick wall, blowoff header, etc., there will be severe strains set up in the blowoff pipe. This has caused many broken elbows and bent pipe.

In connecting up the blowoff pipe, care should be taken to see that the opening through the back wall of the setting is large enough to clear the blowoff pipe on all sides. An opening of an inch or so between the pipe and wall in directions is none too much. Air leakage

can be stopped by filling in on the outside with asbestos cement such as pipe covering softened in water. This will give readily under pressure and leave the pipe free to move with the boiler.

The outside connections, that is, both the feed connections and main to sump, should be made in such a way that the blowoff pipe would not be held rigid. This can be done by using the "swing joint" principle and so leave the blowoff pipe free to move with the boiler.

There is a possibility that the trouble is caused by opening or closing the blowoff valves too rapidly.

By putting an "unbreakable" elbow in the blowoff pipe, the trouble may be stopped there only to appear in a worse form at the flange where the blowoff leaves the boiler.

The V-shaped brick pier in front of the blowoff pipe is always advisable, though in cases where the boilers are normally fed through the blowoff pipe, they probably do little good.

In cases where boilers were fed from the front and the blowoff became filled with scale, I have seen protected blowoff pipes become red hot without injury. Had there been no brick protection the pipes would probably have been heated sufficiently to cause bulging and bursting.

If the normal feeding is through the blowoff pipe, there will probably not be sufficient temperature variation to cause breaking of cast-iron fittings. I have never seen trouble with blowoff pipes that were kept clean and free to come and go with the boilers.

C. E. M.

H. B. SHOULD LOWER the height of the pier so as not to come in contact with the boiler. Also he could try to rearrange the blowoff piping so as to eliminate the various angles shown, and do away with the elbows by using the 45-deg. ells between the boiler and tee shown in 4-in. line to sump, and do not reduce the blowoff piping from 4 to 1½ in.

There should be a plate riveted to the inside of the boiler, tapped for a 2½-in. pipe connection and a 2½-in. pipe with a "Simplex Seatless Blowoff Valve," located say about at floor line and run to 4-in. line shown in his sketch, using malleable or wrought iron fittings throughout.

F. E. BACON.

THE DIFFICULTY that H. B. has had with regard to cracked elbows on blowoff pipes could be entirely eliminated by simply making a right-angle bend in a piece of pipe and screwing into boiler on the lower end; then attach a sleeve on and add required amount of pipe.

W. J. KERSHAW.

IF H. B. WILL USE a quarter turn bend in place of an ell and a long turn single sweep tee in place of the tee shown, he will encounter no more trouble, as the breakage mentioned is undoubtedly caused by the water heavily striking the blank flange as the blowoff valve is opened. The long sweep fittings allows for expansion and gives an easy passage for the water.

P. H. WAYNE.

NOT KNOWING actual conditions as to rear setting, pipe and wall clearance, I would suppose that in course of expansion of the boiler the horizontal run of 4-in. pipe formed a lever causing unusual strain on the threads of the elbow which, together with the water hammer in blowing off, probably caused the trouble.

The use of an extra heavy 2-in. blowoff pipe and necessary steel flange on boiler shell and plenty of horizontal and vertical clearance would undoubtedly help materially. The V pier should have about 4 in. clearance from pipe and ½ in. clearance from the shell. Or a 4-in. steel sheet ell could be attached to the bottom end of the 4-in. vertical blowoff nipple and do away with the 4-in. ell and horizontal nipple. It may also be advisable to use a slow closing blowoff valve.

R. W. J.

WITH REGARD to the inquiry, "Why the cracked blowoff elbow?" on page 945 of the Dec. 1 issue, I would suggest that, if it is convenient, the blowoff piping should be as straight away as possible.

In the sketch, it shows five sharp turns, and it looks like a very rigid connection. I would put a 4 by 1½ by 4-in. Y in place of the tee in the sump line, and a 45-deg. elbow next to the blowoff valve. Perhaps the piping does not line up and there is undue strain on it. Owing to the range in temperature of the feed water, the expansion and contraction are quite severe.

That steel elbow will hold, no doubt, but look out for the piping; it is apt to break off at the threads.

Some manufacturers make special casings of insulating material for blowoff piping, which is easy to put on and take off when desired.

I would also like to state that perhaps he got a poor lot of fittings; they do run bad in the throat sometimes.

C. L. RAWSON.

Criticism of Ammonia Compressor Cards

IN THE Dec. 15 issue of Power Plant Engineering, page 982, G. P. H. submits two sets of indicator cards, taken from a York "piston type ammonia compressor." G. P. H. evidently means a York ammonia compressor, driven by a piston type engine.

The question naturally arises whether the cards were taken from the steam cylinder, or from the compressor cylinders of this particular machine. It could be either one from the appearance of the cards, but I rather think they are from the steam end.

The cards clearly show that the spring used was too light for the pressure, which caused the indicator pencil to strike against the upper or limit stop pin on the pencil motion, causing the upper straight lines on the diagrams.

For best and accurate results in taking indicator diagrams, use a spring in the indicator, approximately half of the working pressure of the cylinder to be indicated, for instance for 150-lb. steam use a 75-lb. spring. This will give you a card 2 in. high. Personally I prefer a spring ⅔ of the working pressure; as, for instance, on 150-lb. steam, a 100-lb. spring. This will give a card 1½ in. high.

If G. P. H. will follow the foregoing suggestions and take another set of cards, and give the scale of spring used, also steam or ammonia pressure, a more complete and satisfactory diagnosis of the cards can be made.

C. E. ANDERSON.

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Coal Supply Problems

At no time in the history of this country, with its almost unlimited supply of coal, has there been such a famine among users as exists today. The causes, as we see them, for such a condition are several. At the mines, labor has been reduced by the call of many to the National Army, by the better pay received for factory work of the same grade, by the cessation of immigration from European countries and by strikes and other labor troubles at the mines.

While the labor troubles have been a serious handicap in the mining of coal, they are of minor importance compared to the reduction in output classed under the general head of car shortage. As is well known to most of our readers, bituminous coal is mined only as fast as it can be shipped. There is, in fact, no advantage in storing coal at the mine, for not only does it necessitate double handling but causes the deterioration of the quality of the coal. Car shortage has been and will probably remain during the period of the war the most serious interference with the industrial output of the country as well as the progress of our war activities. We are told that ships are waiting loaded at the docks ready for their journey across the waters except for a coal supply, while the railway yards are congested with war supplies which prevent coal from reaching the ships. Again in the railway centers that are virtually the gates through which the coal must pass from the mines to the industrial cities and sea ports a congestion exists which with the employment of every railway facility available is not relieved under the present stress. One cause for this congestion aside from the abnormal amount of shipping toward our sea ports is the demand in our western and middle states for coal mined in the East, thus coal from the East meets coal from the middle West, necessitating thousands of car-miles of apparently useless shipping. Added to these difficulties which might exist at any time of the year, we are experiencing one of the most severe winters the country has ever known, calling for more coal for heating and tying up all inland water transportation.

That such districts as Ohio, eastern Michigan, New York state and the New England states should be the most seriously affected by coal shortage would indicate that lack of usual foresight or interference with deliveries has played a part detrimental to the whole country.

A situation so serious that the National Fuel Administrator will issue such a drastic order as to shut down factories and close up offices with less than a week's notice, demands a thorough study of the causes of such a condition and courses of action which will prevent such occurrences in the future. Engineers must consider it as an individual or personal problem.

For those plants that have no coal in storage at the present time, there is little chance for relief until the situation eases up. The immediate course is evidently to get in touch with the local fuel administrator, put your needs squarely before him and demand consideration. Study your load carefully to determine where power or steam might be saved, then draw up a set of rules governing the use of electric current or steam and enforce them rigidly. The boiler room demands the most attention and the firemen should be directed and given all possible assistance that knowledge of the conditions and

available instruments will afford for securing highest economy.

Looking to the future, furnaces should be made adaptable to the fuel mined nearest to the point of consumption or where the transportation line is most direct. This applies not only to boiler furnaces but house and apartment building furnaces as well. To carry out this suggestion in the middle west may cause some expense and inconvenience on the part of the householder, also some experimentation to determine the best type of furnace and one which will give smokeless combustion, but the results will undoubtedly be worth while.

As early as possible after the close of the heating season the next season's coal should be stored. This is a policy which has always been recommended by the editors of Power Plant Engineering and many articles have been published giving directions for best methods and describing important coal storage yards and equipment. Where vacant space is available near the plant, the storage problem is easy of solution, but for office buildings there is seldom more storage space than will meet the immediate needs of the plant. For such plants arrangements can usually be made with some local storage yard company for rented space. Failing in this, there is the possibility open to many plants of storing in unused basement space, but by all means anticipate the needs of the plant for the coming winter during the spring and have your coal delivered during the summer when the demands are at a minimum and transportation and delivery of coal are carried on with the least difficulty. Coal for domestic consumption should be handled in a similar way.

Helping Sam

Just as a reminder of the part that each can play in helping the war for liberty, the plea of the Food Administration is for a wheatless day on Wednesday, and one wheatless meal on every other day; a meatless day on Tuesday, and one meatless meal each day; a porkless day on Saturday using no fresh or salted pork, bacon, ham or lard; not over 3 lb. of sugar per person per month.

At present prices of food stuffs, few are likely to engage in the pastime of hoarding. If we can get the wherewithal to pay for the day's or the week's needs, we are fortunate. But the substitution of corn, rye, oats and barley for wheat, in whole or in part, will give a cheaper and more wholesome diet, and at the same time release wheat for shipment to soldiers and allies abroad. All our normal surplus of wheat has been sent, and any further shipments must be of wheat saved by voluntary substitution of other grains in our use of foods, thus reducing our home consumption. "Over there" they are now mixing as much as possible of other grains with wheat to eke out the supply, and yet are short of the amount needed.

Twenty-five per cent more meats and fats are needed by the allies than are usually sent. Their farms have yielded less, because of lack of labor to cultivate the land, and the United States is the source from which the deficiency must be made up.

Fish, eggs, fruit, rice, vegetables, will take the place of meats for us, but cannot well be sent abroad. Less pastry and fried foods will help our stomachs, our pocket books and our friends.

Everyone should eat amply for nourishment, to maintain full productive power, but not at all for gratification of appetite. No waste, and simple living is the rule for the real loyal, patriotic citizen. Simple food, simple clothes, simple pleasures. Work hard, play hard and act courageously. We have a victory to win.

Do You Know?

Under what circumstances air cooled in a conditioner is preferable to brine coil refrigeration? How cooled air should be circulated? What and size of equipment necessary for this system of refrigeration?

How to operate the fire extinguishers in your plant without reading directions and where they are located?

The analysis of the coal you are burning? How to interpret this analysis? What mine or locality it comes from? What it costs to evaporate your water?

The essential qualities of coal that can be pulverized? How this process is carried out? How to design coal pulverizing and burning equipment for your plant using commercial apparatus as far as practicable?

To measure the flow of air or steam in your pipe lines by means of the Pitot tube?

How to install electric conduit lines in marshy ground?

How to start an induction motor intelligently?

The essential features of an absorption refrigerating machine?

What metals are used for bearings and the qualities of each? How to apply these metals?

A simple method of drawing the theoretical expansion line of an indicator card?

That the use you make of the information given in this issue is a measure of your engineering ability? Don't pass it up with the hasty thought that you cannot apply it to your plant, you may be somewhere else tomorrow.

SCARCITY OF FUEL in Sweden has forced the investigation of every possible source of supply, and an organization has recently been formed to produce coke from peat. In the course of process, by-products such as sulphate of ammonia, wood alcohol, creosote and lubricating oils have been produced, and the gases from the distillation process have been used for the production of electric power, and for heating ovens and distilling retorts. The coke produced has about twice the heat value of the ordinary peat fuel or powder, burns without smoke and leaves no slag. The cost of production, under conditions in Sweden, is low owing to the value of the by-products obtained, and will probably be from $2.70 to $3.25 a ton.

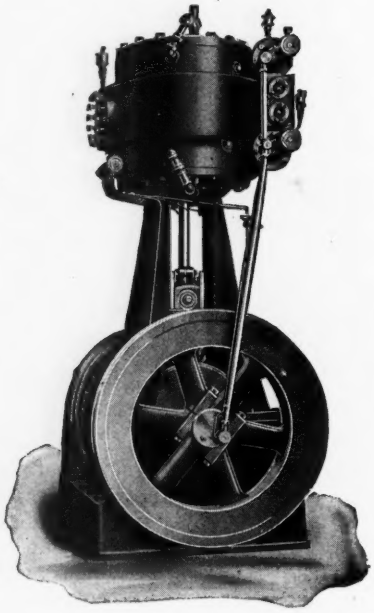
Part of the new system is the improved method of excavating peat, which utilizes an automatic excavating machine, enabling the production of 100,000 tons of air-dried peat by the labor of 80 men, which by hand work would require a force of 800 men.

TO BURN soft coal in house furnaces, use the smaller sizes. Wet coal thoroughly before firing. After filling firepot with a charge of green coal poke a hole through bed to the grate with a broom stick. This permits burning of the volatile gases.

Wheeler Vertical Rotative Dry Vacuum Pump

THIS vertical type of dry vacuum pump, manufactured by the Wheeler Condenser & Engineering Company, of Carteret, N. J., is in demand by ship and stationary plant builders who are anxious to save as much space as possible, and who at the same time have their eyes open to economy.

The pump shown was recently shipped by the manufacturers for installation in an American navy vessel.



ROTATIVE DRY VACUUM PUMP FOR NAVY VESSEL

Another is in course of completion and will soon be shipped.

Where much condensing is to be done and where high vacuum is to be maintained, it is generally best to install separate condensate and air pumps. Thus a motor or turbine-driven centrifugal hot well pump can easily take care of the condensate while this Wheeler dry vacuum air pump withdraws the air.

As the photograph distinctly shows, the inlet valves of this pump are of the semi-rotative type, which are so manipulated by the valve gear as to draw air from the condenser during its full stroke. Clearance difficulties are eliminated in this design of valve gear by providing ports which register with an equalizing passage. The discharge valves are of the poppet type and are easily accessible. In fact, all parts are easily accessible, a point that is of great value in high-vacuum pumping machinery. Valve arrangement is such as to insure perfect drainage at all times.

A motor-driven dry vacuum pump has numerous other advantages over direct steam drive, among which are: Ease of installation, less attention is required, no steam pipe radiation losses, and improvement of plant load factor. A few years ago it was argued that motor drive was poor practice because of the long train of elements through which power must pass before reaching the motor—the engine, generator, transmission lines, switchboard, etc.; but today shut-down troubles have practically vanished and authorities are strongly recommending motor-driven auxiliaries such as this dry vacuum pump.

A-Jacks Steam Damper Regulator

THIS regulator graduates the position of the damper in accordance with the steam pressure, and operates directly on the steam pressure of the boiler, using only steam and exhaust lines.

The piston, which has a 3½-in. cylinder and a 10-in. stroke, is controlled by the governor mechanism mounted on the front side of the regulating cylinder, as shown in

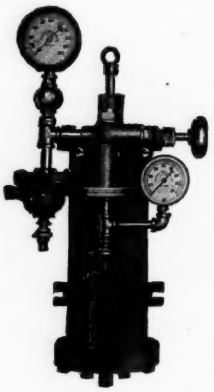


FIG. 1. EXTERIOR VIEW OF A-JACKS STEAM DAMPER REGULATOR

Fig. 2. Steam entering the governor valve through the connections at the left, seats check 2 and tends to unseat the ball valve 3. The ball valve is held against the seat by a spring and when the boiler pressure against the ball is sufficient to overcome this spring, it forces the

ball from the seat and allows the steam to pass down underneath plunger 6. Raising plunger 6 tends to unseat valve 2, allowing the steam to pass into the cylinder through port 7, forcing the piston rod downward. When the pressure within the boiler drops slightly, ball 3 returns to the seat and the pressure under plunger 6 escapes through the small hole in plunger 6 to the exhaust, allowing the steam to escape from the cylinder back through the port 7 between the faces of the check 2 and the small plunger. In the center of the small plunger is a passage leading to the exhaust port, which allows the piston to rise and again open the damper.

The regulator can hold the piston in any position required to maintain a constant steam pressure within the boiler, for steam pressure from 15 to 175 lb.

On the left-hand side there is a strainer to prevent the sediment from passing into the regulator and above this is a gage showing the true pressure of steam in the boiler without any static water head. The small auxiliary gage is merely to show the pressure under the plunger 6 and this pressure never need exceed 10 lb. when in operation.

The regulator is mounted on a neat wood panel provided with expansion bolts and lubrication for the steam supply.

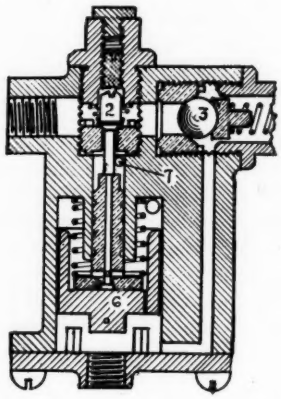


FIG. 2. CROSS SECTION OF REGULATOR SHOWING WORKING PARTS

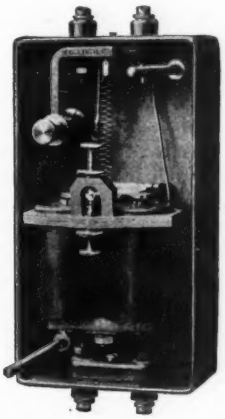
The device is made by the National Regulator Co., of Chicago, Ill.

Direct Current Overload Relay

THE RELAY shown herewith has been developed by the Westinghouse Electric & Manufacturing Co., to give overload protection on direct-current circuits. It is particularly applicable for use in connection with 3-wire generators having but 4 cables running to the switchboard, as by connecting the control coil of the relay to ammeter shunts, the circuit breakers can be mounted on the switchboard, yet controlled by the actual armature current as required by the Fire Underwriters. Without the relay the circuit breaker must be inserted in the circuit at the position of the ammeter shunt, thus necessitating the circuit breaker being mounted at the generator, away from the switchboard, or an extra pair of leads being run from the generator to the switchboard.

The operating part of this relay which is known as type TO is a small 2-pole electro-magnet with special winding. In operation, the pull of the relay coils is opposed by a helical spring; when the pull exceeds the tension of the spring, the contacts close. A calibrated adjustable arm is used to adjust the tension of the spring to regulate the voltage drop across the ammeter shunt at which the contacts will close. When the circuit breaker trip coil requires more than this, an auxiliary relay switch should be used.

These relays can be used with a standard 50-millivolt ammeter shunt (the same shunt that is used with the ammeter), without affecting the readings of the ammeter appreciably. They are calibrated for adjustment to close contacts at from 40 to 80 millivolts, corresponding to 80 to 160 per cent of full load, according to an adjustable scale provided within the instrument allowing adjustment for all intermediate values.



WESTINGHOUSE DIRECT-CURRENT OVERLOAD RELAY

Where a relay is used, the circuit breaker should have auxiliary contacts to open the trip circuit when the breaker opens, relieving the relay contacts of this duty.

GUY E. TRIPP, of New York, heretofore chairman of the Westinghouse Electric & Manufacturing Co., has been given a commission as Colonel and appointed by the War Department as chief of the production division of the Ordnance Department, intrusted with the task of supervising and stimulating the production of all ordnance supplies.

The appointment of Mr. Tripp is one of the important steps in the re-organization of the Ordnance Bureau, announced recently by its chief, General Crozier.

Mr. Tripp was selected because of his experience in the manufacture of munitions of all kinds, the Westinghouse Co. having obtained large contracts from the British and Russian governments immediately on the outbreak of the European war. Mr. Tripp is credited with bringing to the department the highest obtainable type of experience and ability to insure speedy and careful production of munitions. The board of directors of the Westinghouse Co. has given him a leave of absence for the duration of the war.

NOW THAT we can make glycerine from sugar and grain alcohol from sawdust, we can expect almost anything from science.—The Gas Engine.

Book Reviews

PRACTICAL ELECTRICITY, by Terrell Croft; 646 pages, 166 illustrations; New York, 1917; price $2.50.

Practical Electricity, as stated by the author in the preface to this book, was prepared primarily to present the fundamental facts and theories relating to electricity and its present-day applications in a straight-forward, easily understood manner for study by any man of little mathematical training, who desires to acquire a working knowledge of the subject.

Secondarily it was designed for university graduates who desire a medium whereby they can, with minimum effort, review, refresh and reconstruct in line with modern theory and practice their concepts of electric and magnetic phenomena. And, while the statements and explanations are technically accurate, a review of this volume reveals entire elimination of the use of higher mathematics.

The book is divided into 53 distinct sections, the first of which is devoted to a comprehensive discussion of the relation existing between matter and electricity with particular emphasis on the modern electron theory. Then magnetism, electromagnetism, the magnetic circuit and their uses are discussed, with wherever possible, the electron theory being utilized in explanation. Following this are treated the underlying theories of electricity and electric circuits and the various means of producing electromotive force. Storage batteries and the underlying principles of direct and alternating current generators and motors are handled in a most thorough manner in sections 20 to 43, inclusive, while the remainder of the book is devoted to alternating current circuits and their characteristics, transformers and distribution circuits.

Numerical examples are employed frequently, and in order to make the text as readily understandable as possible, many clear cut illustrations have been introduced. Familiar analogies have been used wherever possible.

STATE SANITATION, Vol. II, by G. C. Whipple, 452 pages, 6 by 9 in., illustrated; Cambridge, 1917. Price, $2.50.

Recognizing the value of the work of the Massachusetts State Board of Health, the author publishes a review of this work. Volume I, a review of which appeared in the July 15, 1917, issue of this magazine, gave a history of the Board and the report of the Sanitary Commission of 1850. Volume II, which is just off the press, is devoted to selections and abstracts from the reports of the board. Quoting from the Foreword:

"In making the selections especial prominence has been given to the subjects of water supply and sewage disposal, for it was in the investigation of these subjects that the State Board of Health of Massachusetts acquired early fame. In these writings, the names of Nichols, Mills, Stearns, Drown, Sedgwick, Hazen, Goodnough and Clark stand out prominently. But the reprinted writings include also inspiring addresses by Dr. Henry I. Bowditch on the subjects of public health, preventive medicine, the physician of the future, and intemperance; the statesmanlike reports of Dr. Henry P. Walcott on such great metropolitan improvements as the water supply and sewerage of Boston and its suburbs, and the Charles River Basin; the wonderfully exact scientific investigations of Dr. Theobald Smith in the field of bacteriology; the careful statistical researches of Dr. Samuel W. Abbott; the dairy studies of the impetuous Secretary, Dr. Charles Harrington, as well as some of the more modern writings on infantile paralysis by Dr. Mark Richardson and food inspection by Mr. Hermann H. Lythgoe.

"The abstracts are arranged chronologically in order that the reader may obtain a better perspective of the studies with which the sanitarians of the State Board of Health were concerned at different periods of its history."

This book presents, in an interesting manner, information heretofore not available to many interested in sanitary problems and is of especial value to those connected with city water filtration and pumping plants, and sewage flushing, disposal or reduction plants.

THE MODERN GASOLINE AUTOMOBILE, by Victor W. Page; 1032 pages, 1000 illustrations, 13 folding plates; seventh edition, New York, 1918. Price, $3.

Former editions of this book, which has proven to be an invaluable, practical and comprehensive treatise relative to principles pertaining to gasoline automobiles and their component parts, have been reviewed before in these columns. The major portion of this edition remains unchanged; but owing to the highly developed state at the time it was prepared, it has been found desirable to include much additional matter in this latest edition in order to keep pace with the progress of the industry. The entire work has been thoroughly revised and a number of corrections made in the text. Much supplementary matter has been added relative to ignition, the action of generators and basic principles on which they operate, so this subject should be easier of comprehension. Entirely new material has been written on tractors in three and four-wheel forms, cyclecars and agricultural tractors or automobile plows; combination gasoline-electric drive, front-wheel and four-wheel drive and steer systems, and other important developments in power-propelled vehicles. The discussion of power transmission methods has been augmented by consideration of the skew bevel gear and two-speed direct drive rear axle, as well as several new forms of worm gear drive. The subject of electrical motor starting systems has been considered at length and leading systems and their components described. A discussion on ball and roller bearings, their maintenance and installation, has also been included, and a number of other features of timely interest, such as latest types of gasoline and kerosene carburetors, cyclecar power plants, the Fischer slide-valve motor, detachable wire wheels, etc., have been added to bring the work thoroughly up to date. Many new illustrations have been introduced and the treatment of some of the subjects changed to some extent to permit the work to be used to somewhat better advantage in teaching classes in engineering in various technical schools that have adopted this work as a text-book on elementary automobile engineering.

CENT FOR CENT, we purchase greater food value in corn than in wheat. Corn is one of the commodities that has more nourishment in a dollar's worth than has wheat, which is generally used as a basis for comparing values.

Catalog Notes

COMPRESSORS and vacuum pumps for extraction of gasoline from natural gas, are described and illustrated in Form No. 3118 superseding No. 3018, from Ingersoll-Rand Co., 11 Broadway, New York.

Bulletin No. 9024 describes steam condensing plants consisting of Beyer barometer counter-current condensers, Ingersoll-Rand dry air pumps and Cameron water pumps, and illustrates several typical condenser plants installed for various classes of service.

UNIQUE AMONG CATALOGS is that of the Hayward Buckets for Industrial Plants, Catalog 44, issued by the Hayward Co., of New York City. This shows the use of buckets for coal and ash handling, and for the conveyance of other loose material arranged for monorail hoists, traveling cranes, transfer bridges and other installations. Various types clamshell buckets are shown, and blue print arrangements of plants for handling from coal car to storage, and the reverse, and from either storage or coal car to the boilers. The illustrations are clear and interesting, and the blue prints give good ideas of the various types of storage and transfer plants that are used in power installations.

CATALOG "E" describing Hydro Gas Meters has recently been published by Bacharach Industrial Instrument Co., Pittsburgh, Pa., and contains valuable information for managers, superintendents and engineers. First is given a review of the various methods employed for measuring gases, such as impact and pitot tubes, orifices, nozzles, venturi tubes, etc., cuts being used to illustrate these methods. It is pointed out that in each of these devices, the differential pressure is the quantity to be measured, and then follows a description of the Hydro instrument which measures and records this differential pressure accurately. By varying the proportions of the instrument, any desired magnification of the differential pressure can be obtained. The instrument is also made portable for use of the testing engineer and the efficiency expert.

THE RHODE ISLAND UNION with the bronze seat having octagonal ends and threaded to standard Briggs pipe thread sizes, is fully illustrated and described in a booklet issued by the Rhode Island Fittings Co., Hillsgrove, R. I. These unions are guaranteed for 300-lb. working pressure, for steam, water, gas or oil, and are made in all types.

CONCRETE SHIPS, a Possible Solution of the Shipping Problem, is the title of a pamphlet recently published by Portland Cement Association, 111 West Washington St., Chicago, containing 46 pages discussing the development of concrete boat making, recently proposed methods and advantages of concrete ships.

THE GENERAL ELECTRIC CO., in Bulletin No. 41,021, describes the R. F. line of adjustable speed motors, which are the results of many years of experience and numerous tests under actual shop operation. Two special advantages mentioned are the practical elimination of commutation troubles arising from abuse or careless operation; secondly, the main field coils are so designed as to withstand, without injury, full potential continuously with the armature at rest; special attention has also been given to the efficiency regulation, stability and insulation. An interesting alphabetical arrangement of the various parts of the R. F. motor, together with illustrations and dimensions, will be found on pages 6 and 7 of this bulletin.

BULLETIN 130 of Inter-State Machine Products Co., Inc., Rochester, N. Y., contains 12 pages with illustrations, price list, and description of the installation of Sterling force feed lubricators for lubricating valves, cylinders, bearings of engines, pumps, air compressors and similar units.

FROM LINK-BELT CO., 39th St. and Stewart Ave., Chicago, we have just received the company's latest publication, No. 299, on Link-Belt Silent Chain for rubber mill machinery.

DIXON'S SILICA-GRAPHITE PAINT, Its Physical Properties and Especially the Wide Difference Between It and Other Protective Paints, is the title of a new booklet gotten out by the paint department of the Joseph Dixon Crucible Co., Jersey City, N. J. This booklet contains 24 pages of interesting reading, showing why Dixon's Silica-Graphite Paint is of value for all

protective purposes. It deals with the paint problem from an entirely new angle, and anyone contemplating using a paint for protective purposes where unusual difficulties exist will find this booklet invaluable. To anyone who has an interest in protective paint as a means of preserving property, this booklet will especially appeal. Ask for Booklet No. 96-1B.

UNDER THE TITLE How Anyone Can Make a Jointless Gas-Tight Furnace Lining, the Betson Plastic Fire Brick Co., of Rome, N. Y., has published a 16-page illustrated folder showing how the "plastic fire brick" made by them is used in forming one-piece linings for steam boiler furnaces. The old lining of fire bricks or blocks is first removed and the plastic material is then placed in the form of chunks, consolidated with a mallet and smoothed with a trowel, occupying the same thickness as the old lining. After the material has been dried and set by a slow fire for 4 or 5 hr., the furnace can be put into full service. The same material is used for forming baffles in water-tube boilers.

DEANE OF HOLYOKE steam and electric single, duplex and triplex automatic pumps and receivers are described and illustrated in Catalog D-1301 of Worthington Pump & Machinery Corporation, 115 Broadway, New York.

CHAS. A. SCHIEREN CO.'S 1918 50th Anniversary Calendar, showing bird's eye view of lower Manhattan skyline from the East Side, was lately received.

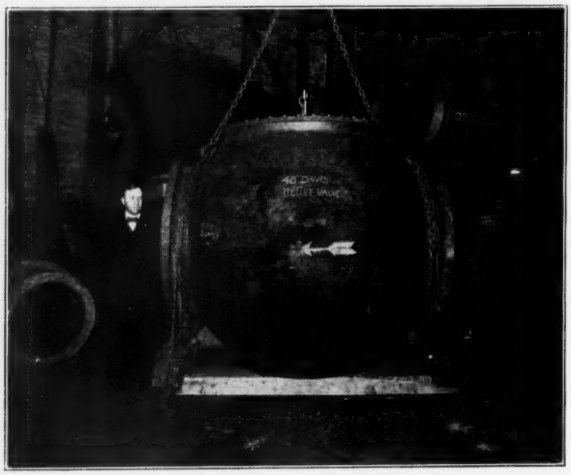
FROM CONDENSITE CO. OF AMERICA, Bloomfield, N. J., we recently received a booklet which gives a brief outline of the properties and illustrates some of the uses of condensite.

A BOOKLET relating to Starrett micrometers, Vernier caliper squares, dial and test indicators, surface gages and other instruments made by L. S. Starrett Co., Athol, Mass., is being sent out by that company.

Trade Notes

ONE OF THE LARGEST relief valves ever manufactured was recently built for the Conners Creek Plant of the Detroit Edison Co., by the G. M. Davis Regulator Co., Chicago.

It is a 48-in. horizontal exhaust relief valve, is hydraulically operated, and will serve as a safety relief for the condenser on a new turbine unit. The complete valve weighs 14,000 lb. and measures 7 ft. 5 in. from face to face of the flanges.



The valve disc, 48 in. in diameter, is made of cast iron, and has a bearing metal face which seats on a brass ring. It is water sealed, and is double-cushioned with brass-lined dashpots above and below the disc. The valve stem is 3.5 in. in diameter. The illustration gives a good idea of the relative size of the valve.

FRANKLIN T. CHAPMAN has removed from Detroit to Philadelphia to assume a position as assistant general sales manager of E. F. Houghton & Co.'s plant. Mr. Chapman, through his experience in the automobile field, has a thorough knowledge of the practical use of oils and other products of E. F. Houghton & Co.

JOHN D. STOUT has been appointed Chicago representative for the Terry Steam Turbine Co. Mr. Stout was at one time assistant engineer of the Terry Steam Turbine Co. and was recently transferred from the New York office, where he was assistant manager.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.

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No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,250.

Technical Publishing Co.

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—By engineer experienced with producer gas and oil engines, a.c. and d.c. equipment, pumps, storage batteries, interior wiring and repair work. Technical graduate. References. Address Box 501, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-1

POSITION WANTED—By young man as oiler in large central station, with 7 years' experience with Corliss engines up to 400 hp., d.c. generator. I. C. S. graduate on complete Steam Engineering. Age 27. Married. Best of reference. Will go any place. Address Box 493, Power Plant Engineering, 537 S. Dearborn St., Chicago. Ill. 1-15-1

POSITION WANTED—As helper or oiler in small or large plant. Will come at once. Sober and industrious. Will consider reasonable salary. Address Box 494, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-1

POSITION WANTED—By young man as oiler or assistant engineer in or around Chicago, with chance of advancement. Eight years' experience; ready to start work at a week's notice; references. Address Box 492, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-1

POSITION WANTED—Chief engineer desires change of location. Competent to handle large plant. Experienced with a.c. and d.c. machinery, irrigating machinery, ammonia compressors (practical ice-making), gas engines and air compressors. Can install and do repairs. Not liable to conscription. Address Box 495, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 10-15-2

POSITION WANTED—As chief engineer. Am familiar with a.c. and d.c. generators and refrigerating and steam heating plants. I desire change. I can furnish good references and have been with present employer about 4 years. Age 35. Single. Address Box 715, Middleton, Conn. 12-1-1

POSITION WANTED—As chief engineer for manufacturing plant by technical graduate. Four years as chief in present plant. Age 30. Married. A1 references. Present salary $1800. R. R. Rogers, 32 Cordova St., St. Augustine, Fla. 1-1-1

POSITION WANTED—As watch engineer in power or ice plant. Ten years' experience. Married and sober. Frank Wells, 210 Pearl St., Jeffersonville, Ind. 1-1-1

Help Wanted

WANTED—Resident subscription agents in the following cities; Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

BOILER ROOM FOREMAN WANTED—For 5000 b.hp. plant, Stirling and B. & W. boilers, induced and natural draft, economizers, chain grate stokers. Must be able to handle operation, maintenance and efficiency work and get results, None but thoroughly competent and experienced men need apply. Middle West city of 60,000. State age, experience, etc., fully and present salary. Address Box 503, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-2

WANTED—Superintendent for Gas Plant—2 benches silica sixes. Must have had 3 yrs. actual experience. Reference required. Good salary. Address Consumers Gas & Coke Co., Waycross, Ga. tf.

WANTED—A competent refrigerating engineer in Western Pennsylvania. Must be familiar with raw water and ice making system and electric machinery. State salary wanted. Address Box 505, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—2 Stationary Engineers with Ohio State License to fire and operate 250 HP. power plant in town of 30,000; salary $110 per month. Also 2 men with Ohio License to operate plant in town of 1200—$105 night engineer, $110 day engineer—no firing. Applicants state present employment and experience. Address Box 506, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 2-1-1

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Marine boilers. We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 hp. to 250 hp. The Pittsburg Boiler & Machine Co., Pittsburg, Kan. tf.

WANTED—Agents to call upon engineers to sell positively the best pump valve on the market. Excellent proposition. Big money maker. Address Box 500, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Agents handling engine and boiler room specialties in every section for our Boiler Girth Seam Protector. Liberal inducements. Give experience and territory covered. Address National Boiler Protector Co., Dayton, Ohio. tf.

WANTED—Desire to purchase a complete set of 1916 copies of Power Plant Engineering (formerly Practical Engineer). State price. Address Bix 504, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-15-3

WANTED to represent at St. Louis, manufacturer selling to mining, machine shop or power plant trade. Office established, long business experience, adequate endorsement furnished. Write 413 Bank of Commerce Bldg., St. Louis. 2-1-1

WANTED—Exclusive agency for machinery or supplies salable to mining, machine shop or power plant trade. Have a well established office; best of references. Only substantial business desired. Write 413 Bank of Commerce Bldg., St. Louis. 2-1-1

For Sale

FOR SALE—250-volt direct connected units; 75 kw. 3 wire 250-125 volt, with Harrisburgh engine, $1800 each; 60-kw. Allis Chalmers-Watertown, $1200; 50-kw. Allis Chalmers-Chandler Taylor, $1100; 50-kw. G. E., 3 wire 250-125 with Harrisburgh, $1350; 37½-kw. Westinghouse-Sninner, $1100; 30-kw. Sprague-Harrisburgh, $900; 25-kw. G. E.-A. & S., $700. Power Machinery Exchange, Jersey City, N. J. tf.

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St. N. W., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Power Plant Engineering. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

Miscellaneous

FACTORY MANAGERS, ENGINEERS AND OWNERS—Coal is high and scarce. Let us tell you how to conserve it and utilize your exhaust steam for heating and drying purposes. Address Monash Engineering Co., 1413 W. Jackson Boulevard, Chicago, Ill. tf.

Sparks From The Advertising Pages

Where Buyers and Sellers Meet

A Court for Buyers of Power Plant Equipment

The 1918 Chicago Automobile Show is just closing as this issue of POWER PLANT ENGINEERING comes off the press.

From all over the country the big men of the industry have foregathered to compare notes, to look at the new models, to glean inspiration and information from contact with one another.

The Auto Show is always the big occasion of the year for the automobile manufacturer, dealer and owner. Especially does it attract the intending buyer.

He comes to the show with the idea of learning something. He wants to make sure, before he lays out his good cash, that he is getting supreme value, making a wise investment. He comes with the idea of forestalling an aftermath of trouble and regret. He wants to avoid buying in haste and repenting at leisure.

When he has carefully gone the rounds, looked over the whole field, and listened attentively to the sales story of each exhibitor, he feels that he is fortified against mistake. He is master of the situation because he has the facts. He can now make his choice with a clear understanding of the points at issue. It is like a case at law in which he is judge and jury and each seller a plaintiff seeking a favorable verdict.

There is no annual show of power plant equipment to which you may go before making your purchases as does the automobile buyer.

But there is a court where buying trials are held—a court where selling arguments are reviewed lucidly, succinctly, interestingly, and with authority. This court sits regularly on the first and fifteenth of every month. The courtroom as you may have guessed is the advertising section of POWER PLANT ENGINEERING, and you, Mr. Chief Engineer, you are, or may be, the judge.

You will find just the same advantages in sitting on this bench as does the automobile buyer when he consititutes himself presiding judge at the Auto Show.

Your understanding of the buying situation will be clarified and your decisions handed down with a sense of certainty that you are right.

It pays to read the advertising pages of POWER PLANT ENGINEERING—that's the moral in plain and few words.

Reading the advertising increases your knowledge, and knowledge is powerful. The more you know about the various lines and products you buy the better buyer you will be. Reading the advertisements in POWER PLANT ENGINEERING is a liberal education in economical buying and may be acquired at he cost of a little time each day.